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EQUIPMENT, TYPE 7000
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CHAPTER 12
RECEIVER R 1363 B

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RECEIVER R1363B

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Incorporation of an Amendment List in this publication should be recorded by inserting the Amendment List number, signing the appropriate column, and inserting the date of making the amendments.

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2.
RECEIVER RL363B

INTRODUCTION

1. The Mk.IIB receiver RL363B is a modified version of the Mk.II receiver RL363. The modifications, besides allowing operation on a number of wavebands and increasing the phasing accuracy, adapt the receiver for use with the Rack Type 36A (Filter - Comparator - Oscillator).^{*} See S.D.0295, Ch.9. A general view of the receiver is shown in Figure 1.

/ or type 52

2. The receiver RL363B can be installed at both Slave and Monitor Stations, although some units are not used at the Monitor Station. There is no special monitor version of this receiver as was the case with the Mark I and Mark II receivers.

3. Interchangeable R.F. units are provided so that the receiver may be operated on several wavebands. Anti-jamming circuits are also incorporated in the I.F. amplifier.

4. 230 volt 50 cycle mains are normally used to supply the receiver, but for emergency use a Diesel generator may be employed. The current consumption is 2½ amps.

5. A number of sets will be mounted in "Park Royal" lorries for use as mobile reserves, in case stations are disabled by bombing.

GENERAL DESCRIPTION

6. The purpose of the RL363B is to receive pulses from the Master Station and Slave Stations and display them on a special accurately calibrated time base. When the receiver is installed at a Slave Station a positive locking pulse is sent down a line to the local Slave transmitter. The R.F. pulse radiated by this transmitter is observed on the cathode ray tube together with the other received pulses. A block diagram is shown in Fig.5.

7. By means of controls on the receiver the local pulse can be made to appear in any desired position on the time base relative to the other pulses displayed upon it, i.e. since the length of the time base represents a definite period of time, the interval between the arrival of the Master pulse and the emission of the Slave pulse can be controlled to within a fraction of a microsecond. The operation of setting the Slave pulse in the correct position on the time base is called "phasing". Once the transmitter has been phased correctly, the setting can be automatically controlled by the F.C.O. to within ± 0.01 microseconds. Alternatively the F.C.O. may be manually controlled either from the Monitor Station by means of Remote Control apparatus (see S.D.0295, Ch.13) or by the operator at the Slave Station. The condition in which the F.C.O. operates is chosen by means of a selector key (Remote - Local - Auto) mounted on the control Desk. A second key is provided by means of which the F.C.O. is manually controlled from the receiver. This key is shown in Figure 2 to the left of the selector key.

8. The following units are fitted to RL363B:-

- Receiver Unit (I.F. amplifier with interchangeable R.F. Units)
- Diode Receiver Unit (on same panel as I.F. amplifier)
- Strobe Gain Control Unit
- Filter Input Unit
- Filter Strobe Unit (Filter Gate Unit)
- A.V.C. Unit
- Divider II
- * Divider III
- * Phase Shifter 3
- Phase Shifter 4 (with separate control box)
- Phase Shifter 5 (used with 1.5 mc/s calibration unit)
- Time Base Unit
- 1.5 Mc/s calibration unit
- Cathode Ray Tube Unit (with controls on separate panel)
- Oscillograph Unit ("O" Unit)
- Power Packs: PP1
- PP2
- PP3
- PP5
- PP6
- PP7
- Fuse and Indicator Panel

* The RL363B MUST be used with an F.C.O. rack

* Not used at Monitor Stations

9. The Units are mounted on a three bay rack as shown in Figure 1. A wooden desk is fitted at a convenient height. The screen of the cathode ray tube is observed through a hole in the desk and certain controls which may require constant attention are also mounted thereon so as to be conveniently near at hand.

10. Each unit has as its basis a Post Office Standard Panel, and in the majority of cases there is a further sub-panel upon which the components are mounted. In some cases, for example the Cathode Ray Tube Unit and Fuse and Indicator Panel, the components are mounted directly on the front panel. Power Packs 1, 2, 3 and 7 have horizontal trays bolted to the rear of the front panel.

11. Many of the component values given on the drawings have large tolerance. In some cases resistances and condensers may not have exactly the same nominal value or rating as is given in this publication; this applies especially to some decoupling condensers, which may have higher capacities than those specified.

12. The approximate maximum dimensions are:-

Height 6 feet 6 inches	Width 6 feet 4 inches
Depth 3 feet 4 inches	The weight is about 15 cwt.

RECEIVER UNIT

13. The Receiver Unit consists of an I.F. amplifier with four interchangeable plug-in R.F. Units covering the following frequency bands:-

R.F. Unit No.32:	20-30 mc/s
R.F. Unit No.31:	40-52 mc/s
R.F. Unit No.26:	50-65 mc/s
R.F. Unit No.27:	65-80 mc/s

The frequency coverages given are approximate only. The overall bandwidth of the receiver is ± 0.5 mc/s at 6 db down each side of resonance. A diode receiver used for receiving the local pulse at Slave Stations is mounted on the same panel as the I.F. amplifier. Figure 3 shows a front view of the receiver panel and Figure 4 a rear view of the same panel. The latter photograph shows an early type of receiver in which terminal blocks were mounted on the I.F. amplifier and Diode receiver in place of the Jones plugs J2 and J3. To make servicing easy a pair of extra flexible leads terminated at each end by 6 pin and 8 pin plugs and sockets are provided so that the complete receiver unit (including Diode Receiver) can be removed from the rack and connected by means of these extension leads to the Jones plugs J2 and J3.

14. R.F. Unit No.31.- The circuit diagram of R.F. Unit No.31, which covers the band from 40 to 52 mc/s approximately, is shown in Figure 6. It contains one stage of R.F. amplification, V1, which is a pentode Type VR65 mounted in the front compartment of the R.F. Unit. V2, the mixer is also a VR65 and is mounted in the middle compartment. The rear compartment contains the oscillator stage V3 which is another VR65. The output from the oscillator valve is injected into the cathode circuit of V2 through T1 which has a band-pass of more than 10 mc/s. The frequency of the oscillator is controlled by L4 and C22, L5 being an R.F. choke.

15. The inductance L3 is fitted with an adjustable iron dust core by means of which the coil is tuned to 7.7 mc/s. This coil together with L1 in the I.F. amplifier (also tuned to 7.7 mc/s) form a band pass coupling of which C10 forms the coupling capacity and C19 the tuning capacity. C19 is the screened lead to the output Plug J1 which is built into the unit. NO ATTEMPT SHOULD BE MADE TO ADJUST THE TUNING OF L3 UNLESS THE NECESSARY INSTRUMENTS ARE AVAILABLE.

16. R.F. Unit No.32.- The circuit diagram of R.F. Unit No.32 which covers the 20-30 mc/s band is shown in Figure 6. It is similar to No.31. The R.F. tuned circuits are damped by R3, R4 and R23, R24. The mixer stage V2 is similar to that in R.F. Unit No.31, L4 being the oscillator output transformer. The oscillator stage V3 is somewhat different. A cathode tap circuit is employed, L5 being the tuning coil and C21 the tuning condenser.

17. R.F. Units Nos. 26 and 27.- The circuit diagram of R.F. Units Nos. 26 and 27, covering 50-65 and 65-80 mc/s respectively are shown in Figure 20. The R.F. and Mixer stages use VR136 (RL7) valves which are special high frequency pentodes having four separate cathode connections to reduce the inductance of the cathode lead. The oscillator valve V3 is a VR137 (RL16) high frequency triode connected in a Colpitts circuit. The R.F. mixer and oscillator circuit are tuned by a three-ganged condenser C4, C5, C32 with the associated trimming and padding condensers. C7 is an externally adjustable trimmer. The output from the oscillator is applied to the grid of the mixer (V2) via C18 together with the R.F. input.

18. I.F. Amplifier.- The circuit diagram is shown in Figure 7 together with that of the Diode Receiver which is mounted on the same panel. There are five I.F. stages, V1 to V5, employing VR65 valves. V6 is the diode detector type VR92. V7 is a pulse-frequency amplifier and V8 and V9 are cathode follower output valves. The grid circuit of V1 consisting of the variable inductance L1 and the coupling condenser C1, forms part of the bandpass coupling between the R.F. Unit and I.F. amplifier and is tuned to 7.7 mc/s. All the other I.F. circuits are tuned to 7.5 mc/s.

19. The first two valves V1 and V2 are provided with variable cathode bias through the resistances R3, R4, R57 and the variable resistance (Gain Control) R29 mounted on the Strobe Gain Control Unit. Strobe Gain and A.V.C. pulses are also fed on to the cathodes of the first two valves. Stages V3, V4 and V5 are fitted with a special "back bias" circuit to enable the signals to be read through jamming. A switch is

provided to enable certain circuit elements to be altered to deal with different forms of jamming. There are four positions, namely N, X, Y and Z., the operation of which is described in paragraphs 22 to 29.

20. With the switch in position "N" the condensers C15, C23 and C32 are shorted out by the switch contacts S2, S5 and S8 which also short the negative H.T. line supply to earth. In this position grid bias to V3, V4 and V5 is provided by the resistors R17, R27 and R35. A dropping resistance R42 is introduced into the screen H.T. circuits of V3 and V4 to limit the gain of these stages to a reasonable value. In this position of the switch the resistor R5 is introduced in series with the Gain Control (mounted on the Strobe Gain Control Unit) to reduce the maximum amplification available, which is unnecessarily large. Strobe Gain pulses are fed in via Pin 3 on the 8 pin Jones plug J2 to cut off the I.F. amplifier for the duration of the B or C strobe upon which the local pulse appears (see para.36 to 42).

21. The filter condenser C42 is shorted out in position N, ~~as also is the filter circuit C55, R52, C51, R53 between the pulse frequency amplifying stage V7 and the cathode follower V8.~~ Outputs are taken from V8 via P3 to the Y1 plate of the C.R.T. through the contacts of the relay (F.S.I) on the Filter Strobe Unit and from V9 via P4 to the Filter Input Unit and A.V.C. Unit. Separate cathode followers are used to preserve good pulse shape on the tube by reducing the capacity loading on the output to Y1.

22. Operation of Anti-Jamming circuits. Referring to the circuit diagram Figure 7, the anode circuit of V3 has a resistance R22 in series with the normal anode load R21. R22 is 100K and R21 5K. The junction point of the two resistors is connected to the bottom end of the grid coil L3 through the 500K resistor R20. L9 and L12 are R.F. chokes. The bottom end of the grid coil is then connected through another 500K resistor R18 to the negative H.T. line which is at 130 or 230 volts negative with respect to earth, depending upon the position of the A-J switch. The junction of R21 and R22 is decoupled by the condenser C16 and the lower end of the grid coil by the condenser C13. Additional decoupling condensers C17 and C15 are included in the circuit in certain positions of the A-J switch, as shown by the letters on the diagram, to increase the decoupling time-constants. A condenser C14 is connected across R20, thus completing a condenser potentiometer between the grid and anode of V3. The circuits for V4 and V5 are similar except that some of the components are of different values.

23. Consider the operation of V3 with the A-J switch in position Z, which is the position for dealing with C.W. and low-frequency modulated C.W. In this position a resistor R41 is connected across the negative rail ~~supply~~ ^{bias} and since the power pack has poor regulation this reduces the voltage from -230 volts to -130 volts approximately. Now the positive H.T. line is at +350 volts so that the potential at the junction of R21 and R22 will depend upon the drop in potential across R22 due to the anode current of V3. The current drawn by R20 can be neglected. In position Z V3 draws 2.3 mA and this will cause a drop of 230 volts across R22, thus putting the junction of R21 and R22 at 120 volts positive. R20 and R18 are equal so that the grid of V3 will take up a potential midway between +120 and -130 volts, which is -5 volts with respect to earth.

24. The Ia - Vg curves of Figure 21 help to explain the operation of the stage. Consider the curve of Figure 21A where a small C.W. jamming signal is applied to the grid of V3 together with the required pulse signal. The C.W. signal will tend to make the valve take more anode current due to the curvature of the valve characteristic. An increase in anode current causes a greater voltage drop across R22 which in turn will make the voltage at the junction of R20 and R18 more negative with respect to earth. The feedback arrangement thus allows the anode current to increase slightly and this increase automatically increases the negative bias applied to the grid so that the point on the valve curve about which the input signal and jamming is applied is shifted sufficiently far to the left so that the required pulse signal can pass through the valve. Figure 21B illustrates the case of a very large C.W. jamming signal. It will be seen that the bias volts have been shifted so far negative that the pulse signal is still able to pass through the valve on top of the jamming signal. The decoupling condensers C16 and C13 are large enough to prevent any change in the bias conditions for the duration of the pulse.

25. If the jamming signal is modulated by a low-frequency sine wave, a waveform similar to the modulation envelope will appear across the anode decoupling condenser C16 since this is of comparatively small capacity and so presents a fairly high impedance to modulation frequencies up to about 4 kc/s. This voltage is fed back to the grid circuit through the condenser potentiometer C14 and C13 causing a reduction in the modulation percentage of the jamming signal which passes through V3. Further reduction in the percentage modulation occurs in V4 and V5.

26. The operation of the scheme for "railing" jamming is slightly different. Figure 21C will help to explain this. In the case illustrated the jamming signal consists of square pulses of somewhat greater width than the required pulse. The A-J switch should be in position X for this type of jamming. This means that the potential of the negative rail will be approximately -230 volts and the anode current taken by V3, V4 and V5 will be about 1.35 mA each with no signal coming through. Extra condensers (C17 and C15 in V3 circuit) are switched in on all three back biased stages, making the time-constants long in the anode and grid circuits.

27. During the period of the "railing" pulses the bias applied to the grid of the valve will not change appreciably owing to the large condensers in the grid and anode circuits. If the required signal pulse happens to occur at the same time as the "railing" pulse, it will be received satisfactorily on top of the jamming pulse as shown. During the gaps in the jamming no pulses will be received but this is not important unless the jamming is locked to some multiple of the recurrence frequency of the signal. Normally the recurrence frequency of the jamming will drift with respect to the signal, so that signals will be received whenever a jamming pulse coincides with the signal.

28. The small amount of the modulation envelope of the jamming signal which comes through the I.F. amplifier is filtered out by C42 and R44. R44 is a high resistance so the charge accumulated by C42 when V₆ passes current can only leak away slowly. Thus the voltage across C42 becomes nearly equal to the peak voltage of the "railings". The diode will therefore pass very little of the jamming but will let through the signals.

29. Position Y on the A-J switch is similar to position X except that the condensers in the grid circuits of the three back biased stages are reduced in value, allowing some negative feedback to take place between the grid and anode circuits. This position is helpful if some low-frequency modulated C.W. is superimposed upon railing jamming. The back bias arrangements will also operate if the jamming signal has sine wave modulation instead of square pulses, but the improvement will not be so good, as owing to the waveform there is less time at the peaks during which signals can be received.

DIODE RECEIVER

30. The Diode Receiver, which is mounted on the same panel as the I.F. amplifier, is used for receiving the pulse from the local transmitter. It is used in preference to biasing back the I.F. amplifier by strobe gain control because in the latter case only the top of the local pulse is amplified by the receiver, and any jitter or unsteadiness is thus magnified, making accurate phasing difficult. Owing to the absence of tuned circuits distortion of the pulse shape due to frequency discrimination is avoided. Two outputs are taken from the Diode Receiver, one to the cathode ray tube (connected in parallel with the output of V₈ on the I.F. amplifier chassis) and the other to a line running to the transmitter hut so that the rectified pulse may be inspected on a monitor, thus showing the shape of the actual pulse transmitted from the aerial.

31. Referring to the circuit diagram Figure 7, the aerial is brought to a Pye Plug P₇ (shown in the photograph Figure 4) which leads to the cathode of the diode V₁. The negative pulse output from the anode is passed through the R.F. filter, C₁, L₁, C₂, L₂ to the grids of V₂ and V₄ via the amplitude controls R₁₉ and R₂₂. The latter control is preset and is mounted behind the removable panel.

32. V₂ and V₄ amplify and invert the pulse and pass it to the cathode followers V₃ and V₅, the former being a VR91 valve which feeds the pulse on to the cathode of V₈ in the I.F. amplifier and thence to the cathode ray tube. V₅ is a VT75, the output from which is taken to the line leading to the transmitter hut via the Pye Plugs P₈ and P₁₃.

33. The amplitude of the pulses must always be kept small enough by means of R₁₉ and R₂₂ to avoid overloading the amplifiers, otherwise distortion will be introduced. The height of the local pulse on the tube should be approximately equal to that of the other received pulses.

34. The time delay experienced by the signals in passing through the I.F. amplifier is about 1.2 microseconds greater than the delay introduced by the Diode Receiver. The exact delay must be determined for each individual receiver and a correction applied to the phasing number.

35. Under certain conditions it may not be possible to receive the transmitter pulse on the Diode Receiver. In this case, the strobe gain control must be adjusted so that the pulse is received on the normal receiver and the amplitude control R₁₉ on the Diode Receiver should be turned to zero. In this case the correction factor mentioned in para. 34 should be ignored. Note that since the signal is small, only a small amount of strobe gain ~~control~~ ^{reduction} is required, thus no jitter is introduced on the peak of the local pulse.

STROBE GAIN CONTROL UNIT

36. This unit provides a controlled increase or decrease of the gain of the receiver for a period of about 100 microseconds coincident with either the B or C strobe time base. It is effective on both main and strobe time bases. At Slave stations the I.F. amplifier is normally cut off for the duration of either the B or C strobe, upon whichever the local pulse appears, and the local pulse is then received by the Diode Receiver. On some sites however, the diode is not sufficiently sensitive, in which case the gain of the I.F. amplifier must be made just sufficient to receive the local transmitter pulse satisfactorily. At Monitor stations an increase in gain may be required to equalise the amplitudes of the pulses being monitored.

37. The Strobe Gain pulses are applied together with the A.V.C. pulses to the cathodes of V₁ and V₂ in the I.F. amplifier (fig.7). Thus a positive pulse supplied by the Strobe Gain Control unit reduces the I.F. gain and a negative pulse increases it.

38. The circuit diagram, waveforms and layout are shown in figs. 8, 9, and 10 respectively. V₁ and V₂ (fig.8) form a multivibrator (or "flip-flop") locked to the B or C strobe edge (fig.9A) from the Time Base unit. V₁ is normally cut off, but is brought on by the positive pulse (fig.9C) developed in the anode circuit of V₂ when the grid of the latter is cut off by the synchronising pulse (fig.9B).

39. When V₁ is brought on, a positive pulse (fig.9F) is produced across the cathode load R₁₃ and a similar negative pulse appears at the anode of the valve. These pulses are applied across a variable potentiometer (R₁₂) through an 8 microfarad electrolytic condenser C₄. The slider of the potentiometer is connected to the grid of the cathode follower V₃ and from the cathode of this valve an output is taken through C₈ to the cathodes of the first two valves in the I.F. amplifier, together with the A.V.C. pulses which are fed from the A.V.C. unit directly on to the cathode of V₃ in the Strobe Gain unit.

40. The amplitude of the Strobe Gain pulses may be set to any value in between the limits of the positive and negative output from V_1 by adjusting R_{12} , which thus provides a control of Strobe Gain.

41. R_{29} is the normal gain control for the receiver. It is the cathode bias resistor for V_1 and V_2 in the I.F. amplifier and is mounted on the Strobe Gain unit for convenience. R_{28} is in series with R_{29} to prevent the bias from being reduced too much.

42. The heaters on this unit are earthed through a centre-tapped pair of resistors. This helps to prevent hum from being introduced into the output. The heaters of all the other units connected to the same LT supply must of course be unearthed. The HT supply for the Strobe Gain and A.V.C. units is taken from a stabilising valve on P.P.2."

(A.L.1)

43. The Filter Input Unit has two functions

- (i) As a gate to prevent unwanted pulses from reaching the Frequency Selector on the F.C.O.
- (ii) To produce a clean pulse of constant amplitude and suitable length to operate the crystal filter on the Frequency Selector, irrespective of the amplitude and shape of the pulse received from the Master Station.

It is thus necessary for reliable operation of the F.C.O.

44. The circuit diagram waveform and layout are shown in Figures 11, 12 and 13 respectively.

45. The pulses from the receiver unit are applied to the grid of V_1 through the limiting resistance R_2 . These pulses are shown in Figure 12A. V_1 is normally biased off by the resistance network R_6 , R_5 , R_3 and the input pulses drive the valve into grid current. This produces a negative pulse of about 200 volts amplitude in the anode circuit. The back of this pulse is lengthened by the time constant of R_4 and the stray capacities across it. This time constant is of the order of $3 \mu s$ and thus lengthens the pulse as shown in Figure 12B, as V_2 will not operate correctly if the received pulse is too short.

46. V_2 works with zero bias and has a shorted delay network in its anode circuit. As described in Appendix 2, a waveform as shown in Figure 12C is produced in the anode circuit. The constants of the network are chosen so that the positive and negative pulses produced are each $3\frac{1}{2} \mu s$ long. The front of the negative pulse (which is not used) corresponds with the rear edge of the pulse shown in Figure 12B, so it is clear that this latter pulse must not be too short. The pulse is made $3\frac{1}{2} \mu s$ long as this is the most effective length for energising the 150 kc/s crystal filter in the Frequency Selector on the F.C.O.

47. V_3 (Type VR116) is the Gate valve. The valve is biased negatively on the control grid and the suppressor grid is heavily biased so that the valve is completely cut off on G_3 . 500 c/s gate pulses from the Filter Strobe Unit are applied to G_3 so that the cut off bias is neutralised for the duration of this pulse - that is for about $5 \mu s$. The position and width of the Filter Strobe Pulse can be adjusted so that it "opens the gate" just before the positive pulse from V_2 arrives at the grid of V_3 and cuts the valve off again on G_3 immediately after the end of the positive $3\frac{1}{2} \mu s$ pulse. This is shown in Figures 12D and E.

48. The diode V_5 and R_{28} serve to square off the top of the incoming filter strobe pulse. V_3 , which is a type VR116 valve, has a specially designed suppressor grid which cuts off at about -10 volts. A standing ~~gate~~ bias of 20 volts is applied to G_3 , and the gate pulse is of considerably greater amplitude. Thus the gate valve is brought on very sharply and when the amplitude of the Filter Strobe pulse exceeds the bias voltage on G_3 the diode V_5 conducts and the excess voltage is then dropped in R_{28} . This gives a square top to the gate pulse and prevents the flow of suppressor current.

49. When the contacts of the relay REL1 are closed the suppressor grid of V_3 is taken directly to the cathode so that there is no bias on it and the gate is permanently open. The valve then acts merely as an inverting stage.

50. V_4 inverts the pulse again. The valve works with a positive bias which removes any kinks which may have been developed in the gate valve. The output from V_4 is a square $3\frac{1}{2} \mu s$ pulse (Figure 12F) which is passed to the Frequency Selector in the F.C.O. and is used to "ring" the crystal.

FILTER STROBE UNIT

51. The purpose of the Filter Strobe Unit is to provide the 500 c/s gate pulse to operate the gate valve V_3 in the Filter Input Unit as explained in para.47 to 49. This allows only those pulses produced from the Master Station signals to pass through and energise the Frequency Selector. The gate pulse is also applied to V_1 in the A.V.C. unit, where it allows only the Master pulses to pass through and operate the A.V.C. circuit.

52. The circuit diagram, waveforms and chassis layout are shown in Figures 14, 15 and 16 respectively.

V₁ and V₂ form a multivibrator circuit, V₂ being normally conducting while V₁ is biased off by R₁ and R₂. A negative synchronizing pip (Figure 15A) from Divider II is fed on to the grid of V₂. This shuts off the anode current so the anode voltage of V₂ starts to rise as the condenser C₂ charges up through R₈ (Figure 15B). This rise in voltage is communicated to the grid of V₁, making this valve conduct. Therefore the anode voltage of V₁ falls sharply and this fall in voltage is communicated through C₃ to the grid of V₂. Thus a cumulative action is set up and the pulse produced at the anode of V₁ has a sharp front (Figure 15C).

53. When the negative sync. pulse has ended, V₂ remains cut off, due to the negative charge on C₃. This charge leaks away through R₇ and P₁ and when the voltage on the grid end of C₃ has risen to the cut off bias voltage of V₂ the valve starts to conduct. The anode voltage of V₂ falls rapidly ~~as C₃ discharges~~ and this fall in voltage is communicated to the grid of V₁ setting up a cumulative action which cuts V₁ off and brings V₂ on sharply, thus giving a steep rear edge to the pulse shown in Figure 15B. This process is repeated every time a negative sync. pip arrives at the grid of V₂.

54. The amplitude of the pulse fed back from V₁ to V₂ can be controlled by P₂. The time taken by C₃ to discharge depends upon the amplitude of this negative pulse, so P₂ provides a coarse control of the multivibrator pulse width. P₁ by controlling the rate of discharge of C₃ provides a fine control.

55. The positive pulse (Figure 15B) from the anode of V₂ is passed to the grid of V₃ through a short time constant circuit C₆ R₂₂. R₂₂ is taken to the slider of P₃ so that the positive voltage at the earthy end of R₂₂ can be adjusted, thus varying the width of the differentiated pulse (Figure 15D) applied to the grid of V₃. V₃ works with zero bias and so the negative pulse appears at the anode as a square positive pulse of variable width (Figure 15E).

56. Since the position of the Filter Strobe pulse corresponds to the rear edge of the multivibrator pulse, altering the length of the multivibrator pulse by P₂ and P₁ will cause the Filter Strobe Pulse to move along the time base. As shown in Figure 15F and G, it should be set so that it will just cover the received Master Station pulses when they are phased to zero on the time base. The length of the Filter Strobe pulse is set to approximately 5 or 6 microseconds, as required, by P₃.

57. The screen of V₃ is loaded with a 4.7K resistor and is connected to the Y₂ plate of the cathode-ray tube through a small condenser C₁₂. This feeds a small positive pulse on to the Y₂ plate and so produces a shallow "trough" in the time base, corresponding to the position of the Filter Strobe pulse. This helps in the preliminary adjustments to the F.C.O. The two-way changeover relay in the anode circuit of V₃ which was used to allow the Filter Strobe pulse to be inspected is now no longer needed. (A.L.1)

A.V.C. UNIT

58. The circuit, waveforms and layout are shown in Figures 17, 18 and 19. This unit provides Automatic Gain Control on the Master Station pulses. The unit only operates when the Master Pulse is inside the Filter Strobe Gate pulse but for convenience the receiver gain is controlled during the period from the start of the A trace to the end of the step and for an equivalent period immediately below on the C trace.

59. The output from the receiver output valve V₉ is applied to the grid of V₁ in the A.V.C. unit, which is strobed on the suppressor grid by the Gate pulse from the Filter Strobe Unit fed in through C₃. The diode V₂ A prevents the suppressor grid from going positive with respect to cathode, thus squaring the top of the Gate pulse. This arrangement is similar to that employed on V₃ in the Filter Input Unit. The Master Station pulses only (See Figure 18A and B) appear inverted at the anode of V₁ (Figure 18C), their amplitude being controlled by R₇, and charge the condenser C₁₄ through V₂ B to a negative potential nearly equal to the peak amplitude of the pulses. The resistance R₁₀ is too high to cause the charge to leak away appreciably between pulses (Figure 18D). This negative potential on C₁₄ is applied to the grid of V₃ via the smoothing filter R₁₁, C₅, ~~and~~ C₁₆, thus controlling the D.C. anode current of the valve.

60. V₄ and V₅ form a Multivibrator which is locked from a 500 c/s negative synchronising pip from Divider D.II. This pip (Figure 18A) is also used to lock the time base, so it corresponds with the start of the A and C traces of the time base. The multivibrator pulse has a length of about 200 microseconds (adjustable by R₂₄) which is sufficient to cover the step on the time base, allowing for the initial black out period. The Multivibrator gives a positive pulse (Figure 18J) at the anode of V₄. (This anode is connected to the anode of V₃).

61. The standing anode current of V₃ is controlled by the amplitude of the Master Station pulses (see para.59) and so the potential to which the anodes of V₃ and V₄ rise during the multivibrator pulse is controlled by the amplitude of the input signal. In other words, the working H.T. voltage on the anode of V₄ is controlled by the grid voltage on V₃, which is in turn determined by the amplitude of the received pulses. Thus if the amplitude of the Master pulses increases, the bias on V₃ increases, its anode current falls and the anode voltage rises. Therefore the positive pulse on the anodes of V₃ and V₄ due to the multivibrator action will increase in amplitude. Similarly if the amplitude of the input signal falls the amplitude of the pulse on the anode of V₃ decreases.

62. This pulse is fed via the cathode follower V₆ to the cathodes of the first two I.F. valves, thus providing a bias pulse which will maintain the receiver output constant during the reception of the Master Station pulses. Once the amplitude of the pulse on the tube has been set to approximately three quarters of the saturation level by adjusting R₇ on the A.V.C. unit (2 to 3 cm deflection should be allowed), the A.V.C. circuit will maintain it at this level.

63. The upper terminal block on the chassis of the A.V.C. unit carries the connections to the post office keys operating the relays on the Filter Input Unit, Filter Strobe Unit and Calibration Unit (See Table 3).

FINE PHASE SHIFTERS 3 and 4

64. The purpose of the Fine Phase Shifters 3 and 4 (so numbered because they replace the Phase Shifters 2 and 1 respectively used on R1363) is to move continuously by means of handles the phase of the 150 kc/s sine wave from the crystal oscillator on the F.C.O. The inputs to the Phase Shifters are fed in parallel from the oscillator, the output from P.S.4 being taken to D.II and from P.S.3. to D.III.

65. The effect of turning the phase shifter controls is as follows:-

When P.S.4. is turned all the pulses seen on the cathode ray tube move along the time base, since the Time Base Unit is locked to the output from Divider D.II. When P.S.3 is turned, only the local transmitter pulse moves, as this is locked from Divider D.III. The circuit diagram of P.S.4 and 3 are shown in Figures 26 and 27 and the layouts in Figures 30 and 29 respectively. An explanatory Vector Diagram is given in Figure 28.

27

66. P.S.4.- The input from the F.C.O. crystal oscillator is fed into a transformer coil L1, which is mounted in the control box under the desk (See Figure 2). Two resistors are connected in series across the secondary and the common point is earthed. The output from the coil is connected across two corners of a phase splitting network C1, L2, R3, R4. This output is represented by AB in Figure 28, and is applied to plates A and B of the special condenser C9. This condenser has four stator plates and one rotor. The output from the other two corners of the phase splitting network is applied to plates C and D of the condenser C9. This output is 90 degrees out of phase with respect to the input voltage and is represented by CD in Figure 28.

67. Now for any position of the rotor plate of C9 (which has no stop to limit its rotation) a certain voltage will be induced upon it from the stator plates. Suppose the rotor is between plates A and D of the stator, rather more under A than under D, then a voltage A1 will be induced upon it from A and also a voltage D1 lagging by 90 deg. from plate D. The resultant of these two voltages is shown as E1 in Figure 28. Now suppose the rotor is rotated to lie between D and B. Then, referring to Figure 28, a voltage D2 will be induced on it from D and a voltage B2 from B, the resultant voltage being E2.

68. Similarly when the rotor is further rotated to lie between B and C and C and A voltages E3 and E4 respectively will be induced upon it. Thus the effect of manually turning the rotor is to continually alter the phase of the 150 kc/s sine wave induced on the rotor plate with respect to the input signal AB. This voltage is amplified by the valve V1 and taken out to Divider D.II. via the transformer coil L4, the primary of which is tuned by C7. The grid circuit of the valve is similarly tuned by L3 and C2.

69. The connections of the phase-splitting network to ^{C9} in P.S.4 are made so that a clockwise rotation of the knob advances the phase of the 150 kc/s output. This effectively "speeds up" the time base so that the received pulses travel towards the right hand end of the time base.

70. P.S.3.- The operation of P.S.3 is similar to that of P.S.4. The connections to the condenser C9 are, however, transposed so that a clockwise rotation of the control knob retards the output. Thus a clockwise rotation "slows down" the operation of Divider III so that the local transmitter pulse moves to the right.

71. The control knob of P.S.3. is mounted on the front panel of the unit, whereas the phase shifting condenser and network of P.S.4. are mounted in a separate box under the desk. A microammeter, which is fitted with a flexible lead terminating in a jack, is mounted on P.S.3. and a clock is mounted on the corresponding place on P.S.4. P.S.3 is not used at Monitor Stations.

DIVIDER D.II

72. The purpose of Divider D.II is to produce pulses at 500 c/s rigidly locked in phase to the 150 kc/s sine wave from the F.C.O. crystal oscillator. These pulses are then used to lock the time base. Locking pulses at 500 c/s are also taken from D.II to the Filter Strobe Unit and A.V.C. unit. 150 kc/s pips from D.II are used to produce the 1.5 Mc/s calibration wave from the Calibration Unit and pips at 15 and 150 kc/s from D.II are fed on to the cathode of the C.R.T. to give bright calibration marks.

73. Figure 23 shows the circuit diagram and Figure 24 the waveforms and chassis layout. The input to the divider is a 150 kc/s sine wave of about 5 volts peak to peak amplitude. This is fed into the first valve V1 through the tuned auto-transformer coil T1 which has a step-up ratio of 1:10. Since the signal at the grid of V1 is of greater amplitude than the valve is capable of handling, the anode waveform of this valve is distorted into a square wave with rather sloping sides due to stray capacities across the anode lead R4 (Figure 24B).

74. V2 is a squegging valve. The square wave from V1 is fed through a short time constant circuit C4, R5 on to the grid so that a positive pip is passed. This makes V2 draw a pulse of anode current

through T₇ which is connected so that this drives the grid more positive. Grid current is drawn from C₄ and C₆ and the grid of V₂ is driven negative by the joint action of the overswing of the grid voltage due to the oscillatory character of the transformer winding and the discharge of C₄ and C₆ due to grid current. Thus the valve is rapidly cut off and C₄ begins to charge up again. (Figure 24C).

75. The time constant C₄ R₅ is chosen so that the grid voltage has nearly risen to earth potential by the time the next 150 kc/s pip arrives at the grid of V₂. Thus the anode current of V₂ consists of a number of pulses of current very quickly shut off. These pips which are of about $\frac{1}{2}$ μ s duration only, are taken as positive pulses from the cathode of V₂ to the squaring valve V₁₄ whence they are fed to the cathode of the C.R.T. to provide 150 kc/s bright calibration pips. An output is also taken from the cathode of V₂ to lock the 1.5 Mc/s calibration unit. The cathode waveform is shown in Figure 24D. A more detailed treatment of the blocking (or "squegging") oscillator is given in Appendix 2.

76. V₃ is the first divider oscillator stage. This consists of a triode valve arranged as a squegger, the anode and grid circuits being tightly coupled by T₂. V₃ is normally biased off by the voltage on its cathode developed across R₁₇. In the grid circuit C₇ charges up through R₉ and R₁₀ and superimposed upon this steady rise in voltage are the 150 kc/s pips from the cathode of V₂. When this voltage has risen sufficiently, V₃ conducts and draws a pulse of current through T₂. This transformer is so connected that the grid is driven more positive and grid current is drawn from C₇.

77. Grid current continues to flow until the grid voltage swings negative due to the joint action of the overswing of the grid voltage caused by the oscillatory character of the transformer windings and the discharge of C₇. The negative voltage on C₇ is rapidly removed by the diode V_{12A} and so the grid end of C₇ is restored to earth potential. C₇ then begins to charge up again through R₉ and R₁₀. The complete cycle of operation is shown in Figure 24E.

78. The voltage on the H.T. end of R₉ can be varied by adjusting P₁. This controls the rate of charging of C₇ and is set so that the arrival of every tenth 150 kc/s pip causes the valve to squegg. Thus V₃ produces 15 kc/s pips at its anode locked to the 150 kc/s pips fed on to its grid. The waveform here is shown in Figure 24F. Positive pips can be seen coming from the cathode of V₂ and a negative pip is seen every time V₃ squeggs and draws grid current. To set up the divider stage, this waveform is observed on the Oscilloscope Unit and P₁ is adjusted so that one negative pip occurs for every ten positive pips, as shown in Figure 24G.

79. The valve V₄ has two functions: as a buffer to prevent interaction between the two divider stages V₃ and V₅ and as bias regulator for V₃. The bias for V₃ is taken from the cathode of V₄, and the grid of the latter valve is taken to a potential divider R₁₅, R₁₆, P₁ across the H.T. supply. Thus if the H.T. voltage rises, the cathode potential of V₄ rises (being a cathode follower) and hence the hold-off bias of V₃ increases. Therefore, since the rate of charging of C₇ also increases due to the higher charging voltage, the various factors tend to balance out and the operation of the divider stage is maintained constant over a fairly wide range of H.T. voltage. In fact, the divider will not slip if the H.T. voltage varies by as much as plus or minus 50 volts.

80. The third winding on T₂ feeds positive 15 kc/s pulses through C₁₀ and the limiting resistance R₆₆ on to the grid of V₄. The output from V₄ is taken from the cathode (Figure 24J) and is used to synchronise the next division stage (consisting of V₅, V₆ and V_{7A}) the operation of which is similar to that of the first stage. P₂ provides the adjustment of the division ratio, which is 5.

81. The third stage consists of V₈, V₉ and V_{7B}. P₄ is the division ratio control which is adjusted to divide by 6. V₁₄ is the calibration valve which supplies 150 and 15 kc/s brightening pulses to the cathode ray tube. As described in para.75 150 kc/s positive pips from the cathode of V₂ are fed on to the grid of V₁₄. 15 kc/s pips from T₂ are fed on to the anode (Figure 24K and L). When the Time Base changeover switch is at "Strobe" or "High Speed" a pair of contacts on the switch short out R₅₃ via the terminal Orange 213 so that V₁₄ amplifies the 150 kc/s pips on its grid. These then appear at the anode together with the 15 kc/s pips and both are applied to the cathode of the cathode ray tube (Figure 24M). In the "Main" position of the time base switch the contacts are open so that V₁₄ is biased off by R₅₃; thus only the 15 kc/s pips are seen on the trace.

82. The valves V₁₀, V₁₁, V_{12B} and V₁₃ make up the Coarse Phase Shifter. This works in the same way as a divider stage. A potentiometer P₅ fitted with a switch is mounted on the front panel. When this switch is open V₁₁ is cut off by the bias voltage across R₄₃, but when the switch is closed V₁₁ starts to take anode current and since the grid and anode circuits are tightly coupled by T₅ a cumulative action is set up and the valve squeggs. The squegging frequency is locked by the 15 kc/s pips fed on to the grid of V₁₁ via the cathode follower V₁₀ so that the coarse phase shifting is regular (Figure 24JJ).

83. The anode waveform (Figure 24KK) consisting of a negative pulse followed by a positive "ring" is passed from the third winding of T₅ through the diode of V_{12B}. Only the positive part of this waveform appears at the cathode of the diode, is differentiated by the variable short time constant circuit C₂₄, C₂₅, R₄₅ (Figure 24LL) and reaches the grid of V₁₃ via the limiting resistance R₄₆. This produces negative pulses (Figure 24MM) at the anode of V₁₃ which are fed to the junction of R₉ and R₁₀ through which C₇ is charged. Thus every time the negative pulse from V₁₃ arrives the charging of C₇ is checked (Figure 24NN).

84. C₂₄ is adjusted so that the duration of the negative pip from the anode of V₁₃ is sufficient to retard the charging of C₇ to such an extent that V₃ squeggs after the arrival of eleven 150 kc/s pips instead of ten. This therefore retards the phase of the 15 kc/s pips leaving V₃ by $6\frac{2}{3}$ μ s every time V₁₁ fires. The number of times V₃ fires per second is determined by the setting of P₅ so the rate of phase shift can be controlled.

DIVIDER D.III

85. The circuit diagram of D.III, which is not used at Monitor Stations, is shown in Figure 25 and the waveforms in Figure 24. The circuit is similar to that of Divider D.II with the following exceptions:-

- (i) The 150 kc/s squegging valve V₂ is replaced by a cathode follower with a short time constant C₄ R₅ in the grid circuit.
- (ii) The division ratio of the second stage is 10 instead of 5, thus giving a 250 c/s output instead of 500 c/s. A fine division control P₃ is provided for the second stage.
- (iii) The calibration pip valve (V₁₄ in D.II) is not required.
- (iv) Three valves V₁₆, V₁₅ and V₁₄ are provided to produce a pulse of about 400 μ s wide and 120 volts amplitude. This is fed through the cathode follower V₁₄ to the transmitter hut to trip the transmitter.

86. V₁₆ is the Pulse widener. The input from V₈ (Figure 24AA) is applied to the cathode of V₁₆ which conducts during the negative part of the cycle and so charges C₃₀. When the negative part of the cycle has ended C₃₀ discharges through the high resistance R₅₃. This gives a waveform, shown in Figure 24BB, which cuts off V₁₅ thus producing a 400 μ s positive pulse at the anode of this valve. This pulse is then passed to the cathode follower V₁₄.

87. From the cathode of V₁₄ an output is taken to a three-position key. With the key in the upper position (OFF) the output is disconnected. In the middle position (INSPECT) a marker pulse is taken through a small condenser C₃₅ via a terminal on the Filter Strobe Unit to the Y₁ plate of the C.R.T. and in the lower position (SEND) the locking pulse is sent down the line to the transmitter hut.

TIME BASE UNIT

88. The circuit diagram of the Time Base Unit is shown in Figure 31 and the waveforms and chassis layout in Figure 32. The traces produced on the cathode ray tube are shown in Figure 43. There are three different time bases available, the Main, the Strobe and the High Speed Strobe time bases respectively. All are produced by the same unit.

89. Main Time Base.- The appearance of the Main Time Base on the cathode ray tube is shown in Figure 43A. The circuit diagram is shown in Figure 31 where all the contacts of the changeover switch are shown in position M. The 500 c/s input to V₁ is taken from Divider II. This input pulse (shown in Figure 32A) is applied to the suppressor grid of V₁, which is connected in a Transitron circuit. The positive pip causes V_{2A} to conduct and draw current from C₁, so that at the end of the positive pip C₁ will be negatively charged and as C₃ of V₁ is connected to C₁ this diverts some of the anode current of V₁ to the screen so that the screen voltage falls due to the drop across R₃. The screen is connected to the suppressor via C₃ so that the drop in voltage is communicated back to the suppressor so that a cumulative effect is set up and V₁ is cut off sharply.

90. The condenser C₃ now discharges through R₃ and R₄, the rate of discharge being adjustable by R₄ ("Square wave") so that the next positive synchronising pulse brings the suppressor voltage above cut off. The process is now reversed and V₁ is brought on sharply. The waveforms at V₁ screen, suppressor and anode are shown in Fig. 32B, C and D. It will be seen that a square wave is produced at screen and anode. This square wave is not symmetrical, as the negative going edge is produced by the rear edge of the locking pulse and the positive going edge by the front edge of the pulse, but this asymmetry is not important.

NOTE.- A more detailed explanation of the Transitron is given in Appendix 1.

91. The square wave from the anode of V₁ is fed to the grid of V₆ via C₁₅ and the limiting resistance R₃₂. V₆ is cut off during the negative part of the square wave so the screen potential is equal to the H.T. voltage but when the positive part arrives the valve conducts and the suppressor voltage falls below cut off due to the Transitron action already described. All the cathode current of the valve flows to the screen, which therefore takes up a very low potential (Figure 32E and F).

92. C₁₇ then starts to discharge, the rate of discharge being controllable by R₇₁ ("A stop, position"). As soon as the suppressor voltage rises above cut off (Figure 32E) the anode starts drawing current so the screen voltage and hence also the suppressor voltage rise sharply. The valve now conducts until the arrival of the negative wavefront from V₁ which cuts V₆ off completely, so that the screen voltage again rises to full H.T. potential. The complete waveform generated on the screen in this manner is shown in Figure 32F. The length of the "step" can be varied by R₇₁ and the amplitude α be adjusted by R₇₂ ("Strobe Space"). This waveform is applied to the Y₂ plate of the cathode-ray tube to produce the stepped double time base.

93. The input to V_{2B} consists of a positive pulse followed by a negative "ring" (Figure 32G). The positive part of this waveform charges C₄ through V_{2B} and this charge then leaks away through R₅ which is a high resistance. The time constant R₅ C₄ is large so that the pulse at the cathode of V_{2B} is longer than the pulse applied to its anode (See Figure 32G and H).

11.

94. V_3 is normally biased off by the voltage across R_{12} , but the positive pulses developed across R_5 make the valve conduct for about 150 μ s. The anode and screen potentials of V_3 therefore fall sharply as C_8 discharges through the valve. When V_3 is again cut off, the anode potential rises slowly as C_8 charges up through R_{10} (Figure 32 I) and the screen potential rises immediately to its original value as shown in Figure 32 J. The anode circuit time constant R_{10}, C_8 is 25,000 μ s and C_8 is allowed to charge up through R_{10} for about 1800 μ s only so the rise in anode potential is nearly linear. The variable resistance R_{66} ("Main T.B. Amp.") controls the potential towards which C_8 charges up when V_3 is cut off and this determines the amplitude of the saw-tooth waveform produced at the anode of the valve. The negative pulse on the screen of V_3 (Figure 32J) is taken to the grid of the cathode ray tube and is used to black out the flyback stroke of the time base.

95. The saw-tooth wave generated by V_3 is only of about 15 volts amplitude, so it is therefore amplified by the paraphase amplifier valves V_4 and V_5 in order to provide a large enough deflecting voltage to apply to the Y plates of the cathode ray tube. V_4 amplifies the saw-tooth and feeds it to the X_1 plate. A fraction of its output is tapped off by R_{19} and R_{20} and is fed to the grid of V_5 , which feeds the X_2 plate. The variable cathode resistor R_{68} ("Paraphase") of V_5 is adjusted until V_5 is giving an output voltage of equal amplitude (but opposite sign) to that given by V_4 . (Figure 32K and L).

96. Negative feedback is provided by R_{17} in V_4 and R_{23} in V_5 in order to improve the linearity. R_{69} provides an X shift control by controlling the mean D.C. level of the output to the X plates. The production of the bright Strobe markers is described in para. 99 and 100.

97. Strobe Time Base.— The strobe time base is produced when all the switch contacts on the circuit diagram (Figure 31) are in position "S". The action of V_1 and V_6 is unchanged. V_7, V_8 and V_9 are the A, B and C strobe producing valves respectively. The input to V_7 is the same as the input to V_6 (Figure 32N) but the output from this Transitor is taken from the anode. When the positive-going square wave is applied to the grid both the anode and screen will start to take current, but since the screen resistance R_{40} is so high (220K) the screen voltage will fall rapidly thus cutting off the suppressor grid and preventing the anode from drawing current until C_{39} has discharged sufficiently (Figure 32.O). The anode waveform (Figure 32P) is thus a negative "spike" coinciding with the arrival of the positive-going edge of the square wave on the grid, a short wait the length of which depends upon the setting of C_{39} , and then, when the condenser has discharged sufficiently to allow the anode to draw current, a square negative pulse lasting until the locking waveform goes negative again. The position of the front of the negative pulse depends upon the setting of C_{39} . ("A Strobe position").

98. V_8 and V_9 operate similarly to V_7 except that the square locking wave applied to the grid of V_9 is taken from the screen of V_1 instead of from the anode, so that this input is effectively in anti-phase. This confines the C strobe produced by V_9 to the lower trace of the time base. The anode waveforms of V_8 and V_9 are shown in Figure 32R and U. The timing of the negative strobe edge B (V_8) is determined by the switch S_3 ("B strobe position coarse") which connects different capacities into the transitor circuit and by the fine control C_{40} . The C strobe edge is similarly controlled by S_4 (coarse) and C_{46} (fine).

99. The outputs from V_7, V_8 and V_9 are differentiated by the condensers C_{31}, C_{30} and C_{26} , each condenser forming a short time constant with R_{62} and R_{78} ("Strobe T.B. period"). The mixed differentiated outputs are shown in Figure 32V. When these are applied to the suppressor grid of V_{10} , which is another Transitor, square negative pulses are produced at the suppressor and screen and smaller positive pulses at the anode, by the usual Transitor action. A condenser C_{27} is connected between anode and grid of V_{10} so that the anode waveform (Figure 32Y) is fed back to the grid thus cutting the valve on and off more sharply. These pulses can be moved along by the coarse and fine position controls so that the A strobe pulse can be set anywhere on the step, the B pulse anywhere on the B trace and the C pulse similarly anywhere on the C trace.

100. The durations of all the strobe pulses are varied by R_{78} ("Strobe T.B. period") which control the discharge time of the condenser C_{32} . The screen waveform of V_{10} (Figure 32X) is tapped down by R_{61} and R_{60} and applied to the cathode of the cathode ray tube. This provides brightening for the strobe time bases to overcome the faintness due to the high speed of writing, and on the Main time base indicates the positions of the strobes by bright markers which can be made to move along the time base by means of the strobe position controls. When the time base switch S_1 is switched to "Strobe" those portions of the main time base lying inside the strobe markers are expanded.

101. V_3 provides the actual deflecting waveform for the strobe time base. In the "strobe" position its cathode is earthed and the grid is taken to H.T. via the leak R_{90} . The square negative strobe pulses from the screen of V_{10} are fed through C_{37} on to the grid of V_3 , thus cutting the valve off. This allows C_7 to charge up through R_{10} . The time constant R_{10}, C_7 is 500 μ s and the valve is cut off for about 80 μ s only, so the rise of voltage across C_7 is nearly linear. When V_3 again draws current, at the end of the negative strobe pulse, C_7 is discharged. The time after which V_3 is cut on again is determined by R_{78} ("Strobe T.B. period") which controls the length of the strobe pulses and hence the duration of the strobe time bases.

102. Figure 32Z shows the waveform at the anode of the time base valve V_3 . Note that on strobe time base the anode potential of V_3 is held down and "pushed up" to produce the deflecting waveform, whereas on Main Time Base the anode voltage is "pulled down" and then allowed to rise back to its original level. The paraphase amplifiers V_4 and V_5 work in the same way in the "Main" position except that V_4 has its bias increased by the introduction of R_{18} and R_{67} into the cathode circuit so that it can deal with the positive-going input and V_5 has its bias resistor shorted out so that it can handle the negative going input from V_4 . (Figure 32 AA and BB). R_{70} is the X shift control which alters the mean D.C. level of the X plates.

103. High speed strobe time base.- An extra fast Strobe Time Base is available with the switch on the upper position. In this case the 0.001 μ F condenser C7 is replaced by C38 which is 0.0003 μ F thus giving a more rapid sweep as the voltage on the anode of V3 rises more quickly because of the shorter time constant C38 R10. There is no change in the rest of the circuit.

1.5 Mc/s CALIBRATION UNIT

104. The 1.5 Mc/s Calibration Unit provides a fine calibration scale for use on the High Speed Strobe time base. It can give either 1.5 Mc/s pips or sine waves as required. It is locked from the 150 Kc/s source feeding Divider II. The phase of the output from the calibration unit can be shifted by means of Phase Shifter 5 which is mounted under the control desk. The scale of the Phase Shifter knob is divided into 10 divisions (each phase shifter is individually calibrated) so that the phasing of any pulse on the time base can be measured to within about 0.0002 or 0.0003 of a division which is 0.01 to 0.02 of a microsecond approximately, by balancing the trough of the sine wave on the peak of a triangular pulse (See Figure 43J). Alternatively a pip can be balanced on the peak of the pulse.

105. The circuit of the Calibration Unit and P.S.5 is shown in Figure 33 and the layout in Figure 34. 150 Kc/s positive pips from the cathode of V2 in Divider II are fed on to the grid of V1 via Pye Plug P.II. This valve is biased back by the voltage developed across the 220K grid leak R4, due to grid current, (see S.D.0169, Chap.2) instead of by the normal cathode resistor and only the peaks of the input pulses are passed. These make the tuned primary winding of L1 "ring" at 1.5 Mc/s. The oscillations induced in L1 decay fairly rapidly between each 150 Kc/s pip, so they are applied through a short time constant circuit C7 R8 to the grid of V2, which has a coil L2 in its anode circuit which is also tuned to 1.5 Mc/s by C11. This gives a sinusoidal voltage of nearly constant amplitude on the secondary of L2, whence it is fed to Phase Shifter 5 through the 4 pin plug mounted on the front panel.

106. The operation of P.S.5. is exactly similar to that of P.S.3 and 4. The output from the rotor of the condenser C2 is fed into an amplifying valve V3 via the Pye plugs P22 and P23. The anode load of V3 is the tuned circuit L3 C13 C17 C16, and this feeds the sine wave to the grid of V4 through C19. The cathodes of V3 and V4 are taken to earth via a pair of contacts on the "Cal.Pips" Post Office key mounted on the desk. In the "OFF" position of this switch (away from operator) these contacts are opened and V3 and V4 are biased off by R18. In the two "ON" positions (Cal. Pips and Sine Waves) the contacts are short-circuited.

107. V4 has a two-way changeover relay in its anode and screen circuits. This is shown in the unenergised position in Figure 33, in which condition the unit gives 1.5 Mc/s pips. It will be seen that in this case V4 works with its anode and screen connected together. The anode load is R20 and this together with the small condenser C25 differentiates the output, giving sharp negative pips which are applied to the Y2 plate of the cathode ray tube. In the sine wave position (switch towards operator) V4 works as a pentode, the anode load being the transformer coil L4.

108. The relay is shown in the diagram in the standard symbolic notation, being shown as a rectangle with its D.C. resistance in ohms (2000) written inside. The reference number REL1 beside it indicates that it is relay No.1 on this particular unit, and has three pairs of contacts designated REL1 1, REL1 2 and REL1 3.

109. No description of the operational method of using this unit is given as the technique is liable to be constantly modified.

CATHODE RAY TUBE UNIT

110. The C.R.T. consists mainly of the various resistance networks for applying the correct working potentials to the cathode ray tube and the input circuits through which the deflecting and brightening waveforms are applied to the appropriate electrodes. The circuit diagram and chassis layout are shown in Figure 35. The following controls are provided:-

- (i) Y shift (R11). This controls the standing potential applied to Y1 and Y2 increasing the potential applied to one as the other is decreased.
- (ii) Astig (R10).- An input from the stabilised H.T. supply from PP3 is tapped down by R10 and applied to R3 and the graphite shield of the tube. By suitably adjusting the voltage the spot astigmatism can be reduced to a minimum and the overall focus of the tube improved.
- (iii) Focus (R12).- The spot is focussed sharply by altering the E.H.T. voltage on A2 until best definition is obtained. The settings of "Focus" and "Astig" are mutually interdependent.
- (iv) Brilliance (R9).- Brilliance is controlled by varying the bias voltage between grid and cathode of the tube, thus controlling the density of the electron beam.

111. The controls are all mounted on the C.R.T. controls panel immediately above the C.R.T. panel. A diode valve V1 is mounted on the unit to provide D.C. restoration, which is necessary to keep the brightness of the tube fairly constant on both Main and Strobe time bases.

OSCILLOGRAPH UNIT

112. A small Oscillograph is provided for general monitoring and in particular for setting up the Dividers. The conventional thyatron circuit is shown in Figure 37, together with the chassis layout. It will be seen that the time base speed is adjusted by the selector switch S₁ and the "Velocity" control R₈. In position 1 of the selector a high speed time base is produced by magnetic deflection, L₁ and L₂ being the deflector coils. In switch positions 2, 3, 4 and 5 the time base sweep is obtained by electrostatic deflection. In this case the positive-going saw-tooth on the anode of V₂ is amplified and inverted by V₃ before being fed to the X₂ plate of the cathode ray tube.

113. The time base must be synchronised by feeding a signal onto the grid of the thyatron. A valve V₁ is provided to amplify the locking signal and to act as a buffer between the thyatron and the circuit under examination. The cathode bias on V₂ may be varied by means of a variable resistance R₁₀. This determines the potential which must be applied to the grid to make the valve strike and thus provides synchronising control.

114. It is necessary to allow the thyatron about a minute in which to warm up before the H.T. is applied. A diode V₅ in series with a relay coil and a resistor is connected between H.T. + and earth. The relay switches H.T. on to the thyatron. When the unit is first switched on V₅ is cold and passes no current so the relay remains open and no H.T. is applied to V₂, but when the valves have warmed up V₅ will pass sufficient current to close the relay and switch H.T. onto the thyatron.

FUSE AND INDICATOR PANEL

115. The Fuse and Indicator (F and I) Panel carries the mains and H.T. switches and fuses with their indicator lamps and the mains voltmeter. The circuit diagram is shown in Figure 39. It will be seen that the neon lamps are arranged so that if a fuse blows the associated lamp is extinguished.

POWER PACKS

116. There are six power packs on the receiver. PP1, PP2, and PP3 are shown in Figure 38, PP5 and PP6 in Figure 40 and PP7 in Figure 41.

117. PP1 supplies E.H.T. for the two cathode ray tubes and also various L.T. supplies. There are two transformers T₁ and T₂ each having E.H.T. winding and three L.T. windings. The E.H.T. windings give supplies of 1,700 volts and 800 volts which are rectified by the diodes V₁ and V₂ respectively. Each supply is smoothed by a resistance and two condensers.

118. PP2 consists of two similar H.T. power packs A and B, which are fed from one transformer which has also three L.T. windings. Each H.T. supply is smoothed by a double filter circuit consisting of two chokes and three blocks of condensers. The second and third set of condensers of PP2 B are mounted on the chassis of PP3 owing to lack of space on PP2. A 500 ohm resistance is in series with L₂ on PP2 A to limit the output voltage.

A stabilising valve is mounted on P.P.2, which feeds part of the "A" H.T. supply to the Strobe Gain and A.V.C. units. This stabiliser is similar to that on P.P.3, which is described in the next paragraph. The potentiometer R₃ is adjusted for minimum hum on received signals." (A.L.1)

output of the power pack with a resistance R₂ in its anode circuit. The valve takes a constant drain from the power pack. Consider what happens if the H.T. voltage tends to rise: the rise will be fed on to the grid of V₂ through C₇. This makes the valve take more current and so the voltage drop across R₂ increases. Thus by suitably adjusting the potentiometer R₁ the voltage dropped across R₂ can be made equal to the rise of H.T. voltage, so that the output voltage which is taken from the anode of V₂ remains constant.

120. Similarly if the power pack voltage falls the valve takes less current so there is less drop across R₂. R₄ applies negative feedback to the valve thus increasing the linearity of its characteristic. R₁ is adjusted by observing the High Speed Strobe time base and turning the potentiometer knob until all the time bases are free from jitter. The choke L₃ and condensers C₈ and C₉ are part of the smoothing circuit of PP2 B, being mounted on PP3 because of lack of space on PP2.

121. PP5 supplies H.T. to the Oscillograph Unit, and PP6 provides energising current for the relays on the Filter Input Unit (F.S) Filter Strobe Unit (F.S.I) and Calibration Unit (Cal.pips). No smoothing is needed. The output voltage is about +100 volts.

122. PP7 supplies H.T. to the Receiver Unit, together with a negative H.T. supply for the anti-jamming circuits. An L.T. winding is also provided. V₁ is the normal H.T. rectifier. V₂ is connected across one half of the secondary winding of T₁ and is arranged to give a negative output which can be set correctly by means of the potentiometer P₁. This negative voltage should be -230 volts in positions X and Y of the anti-jamming switch, measured with a voltmeter consuming not more than 1 mA.

123. Distribution of Power Supplies.— The power supplies are distributed as follows:—

14.

PP1	EHT.	2000V 1000V	Main C.R.T. O Unit C.R.T.
	L.T.	4V 1A 4V 1A 6.3V 0.25A 6.3V 2.6A	Main C.R.T. O Unit C.R.T. V ₁ on C.R.T. Unit Valves in O Unit
PP2	H.T.(A)	350V	Divider D.II Filter Input Unit Calibration Unit
		300V (Stabilised)	Strobe Gain Unit A.V.C. Unit
	H.T.(B)	350V	Diode receiver Filter Strobe Unit
			Divider D.III Phase shifter 3 Phase shifter 4 (A.L.1)
	L.T.(1) (unearthed)	6.3V 10A	Diode Receiver Strobe Gain Control Unit A.V.C. Unit Filter Strobe Unit
	(2)	6.3V 10A	Filter Input Unit Divider D.II Calibration Unit
	(3)	6.3V 10A	Divider D.III Phase Shifter 3 Phase Shifter 4
PP3	H.T.	300V (Stabilised)	Time Base Unit Astig. Control on C.R.T. Unit
	L.T.	6.3V 3.7A	Time Base Unit
PP5	H.T.	300V.	O Unit valves
PP6	100V D.C.		Relays on Filter Input Unit (F.S) Filter Strobe Unit (F.S.I) Calibration Unit (Cal.Pips)
PP7	H.T.	350V	I.F. amplifier and R.F. Unit
	Negative Rail	-230V	I.F. amplifier
	L.T	6.3V 6.5A	I.F. amplifier and R.F. Unit

ADJUSTMENT OF DIVIDERS II AND III

124. Connect the terminals "Y1" and "Sync." on the O Unit and also connect the long wander lead to "Y1". "Y2" should be earthed. The waveforms at the various inspection points of D.II, shown in Figure 24N to Q, are then observed by plugging the wander lead from "Y1" into the inspection point sockets. At I.P.1 on D.II we have the 150 kc/s sine wave from the crystal oscillator on the F.C.O. (Figure 24N) which may be observed with the condenser switch on the O unit in position 2.

125. Inspection point 2 is used to set up the first divider stage, which divides by 10. The O unit "Velocity" and "Sync" controls are adjusted until a steady picture is obtained and the potentiometer P₁ ("Stage 1 divide by 10") is adjusted until the waveform is as shown in Figure 24O, that is until there are 10 positive pips between each pair of negative pips. It will be seen that stable operation is obtained over a range of adjustment of the control. The best position is in the middle of this range.

126. This setting should be checked with the Time Base switch in both "main" and "Strobe" positions, as there may be a small difference between the two readings because the calibration valve V₁₄ may affect the operation of the first divider stage. All the other stages may be set up in either position of the Time Base switch.

127. Stage 2 divides by 5 and is adjusted by inspecting the waveform at I.P.3. with the O unit switch in position 3. The waveform should be as seen in Figure 24P. The control for this stage is marked "Stage 2 divide by 5", and should be set to the centre of the range of correct division.

15.

128. Stage 3 is set up by inspecting the waveform at I.P.4 with the 0 unit switch in position 4. The waveform is as shown in Figure 24Q. P4, marked "Stage 3 divide by 6" is set to the centre of the range over which division by 6 is obtained.

129. After adjustment of the division stages the operation of the coarse phase shifter should be checked. Suppose the receiver has been tuned in and that pulses are visible on the time base. Turning the coarse phase shift control to the right, thus switching on V11, should cause the pulses to move in steps of $62/3$ microseconds towards the left of the time base. This is because every time V11 squeggs, the output of the divider is delayed by $62/3$ microseconds and so the start of the time base, which is locked from D.II, is delayed by the same amount. The speed of travel of the pulses across the time base should increase as the coarse shift control is turned further clockwise, as this increases the frequency of operation of the phase shifter.

130. It may occasionally be necessary to adjust C24 so as to ensure correct operation of the coarse phase shifter, which should work at both extremes of the setting of P1. With the divider controls properly adjusted set P1 so that the first stage is on the verge of dividing by 11 and check that the coarse phase shifter works satisfactorily. Now turn P1 until the first stage is about to divide by 9 and again operate the coarse phase shift control. It may be necessary to increase the capacity of C24 slightly, to obtain phase shift. This can be done with a small screwdriver. Reliable phase shifting will then be obtained at all settings of P1.

131. The adjustment of D.III is carried out similarly to the method given in para.124 to 129. The second stage, however, is set to divide by 10 so that the output pulse occurs at 250 c/s instead of 500 c/s. A fine control P3 as well as the coarse control P2 is provided for the second stage. The waveform at inspection points 2 to 6 are shown in Figure 24 DD to HH. An inspection point for the 150 kc/s input is mounted inside the removeable front cover, at the top left hand corner.

132. Coarse shift operation should be checked on D.III and this is most conveniently done with the "Tx.Mod." switch on D.III in the "Inspect" position so that a marker pulse from the output valve is fed on to the Y1 plate of the tube. In this case, the output of the divider is delayed by $62/3$ microseconds every time the coarse phase shifter squeggs, so the marker pulse on the tube moves to the right. Adjustment of the coarse phase shifter is the same as for D.II.

ADJUSTMENT OF TIME BASE

133. The appearance of the Main, Strobe and High Speed time bases when correctly adjusted is shown in Figure 43 A, D and E. There are in all seventeen controls and a Post Office key switch on the Time Base Unit of which eleven are preset being mounted behind the removable cover. Immediately under the time base panel is a $1\frac{1}{2}$ inch panel on which are mounted the Focus, Brilliance, Astigmatism and Y shift controls for the cathode ray tube. These should be adjusted before setting up the time base. Figure 43A shows the appearance of the Main Time Base. This consists of two traces, the upper one having a "step" at the beginning. Each trace is calibrated by bright 15 kc/s pips obtained from the first divider stage via V14 in D.II. The time interval between these pips is $662/3$ microseconds and they should appear about $3/16$ inch apart on the tube.

134. It is first necessary to set up the "square wave" control R4. This is mounted on the sub-panel inside the time base unit. By plugging the 0 Unit inspection lead into inspection point P2 the square wave at the anode of V1 can be seen (Fig.32D). If R4 is incorrectly set the two halves of the square wave will not be of equal length and the time base will appear as in Figure 43 B or C. When R4 is correctly set, which should occur over at least 90° rotation, the time base will be as shown in Figure 43A.

135. After setting up the "square wave" stage, the 15 kc/s coarse calibration pips can be checked. These should be about twenty-seven on each trace, the other three being lost in the "black out". After this the "A step" control R71 is set up. This varies the length of the step at the beginning of the upper trace and should be set so that there are three coarse calibration pips upon it. The step waveform may be observed at P6 (Figure 32 F).

136. The spacing between the time base traces (and hence the spacing between the strobe time bases) may be adjusted to a convenient size by varying the amplitude of this step waveform by means of the "Strobe Space" control R72. The amplitude of the main time base can be altered by means of R66 ("Main T.B. amp."). This should be set so that the trace just fills the screen of the tube. The deflecting waveform at the anode of V3 can be seen at P3 and is shown in Figure 32 I. R66 adjusts the amplitude of this saw-tooth.

137. The output from the first paraphase amplifier V4 may be observed at P4; the correct waveform is shown in Figure 32K. If the amplifier is overloaded the output will be distorted which will cause the time base to be non-linear. Should this occur the "Main T.B. Amp." control should be used to reduce the input to V4 until a good saw-tooth is obtained at P4.

138. At P5 we have the output from the second paraphase amplifier V5, as shown in Figure 32 L. The "Paraphase" control R63 should be adjusted so as to make the output from V5 of equal amplitude to the output from V4. This is best done by removing V5 and noting the time base amplitude. Then replace the valve and adjust the "paraphase" control until the amplitude of the time base is double its previous value. Also check the operation of R69 "Main (X) Shift".

16.

139. Three "Strobe Markers" should be seen on the main time base. These are bright patches which cover about 30 μ s (slightly more than the distance between two 15 c/s calibration pips) and their positions are controlled by means of the three slow-motion dials giving fine control of the A, B and C strobes and the switches "B strobe position" and "C strobe position" which give coarse control of the B and C strobes. The A strobe marker can be moved over the A trace, that is the region to the left of the step on the upper trace. The B strobe marker covers the region to the right-hand side of the step and the C strobe marker covers the lower trace. R78 "Strobe Period", varies the length of the strobe time bases by controlling the time duration of each strobe. R67 ("Strobe amp") varies the length of the strobe time bases by expanding or compressing them without altering the time duration of each.

140. The switch "Strobe Gain Select" (S2 on the circuit diagram) determines whether strobe gain control is applied to the B or C strobe. The potentiometer R94 or R53 ("B syn. or C syn.") should be adjusted with receiver gain high enough to see the "noise" and the strobe gain control at minimum, until the strobe gain control unit is synchronised correctly. This control also permits a small variation in the length of the strobe gain control pulse to be obtained.

METER READINGS

141. An 0- 250 microamp meter is mounted on the panel of Phase Shifter 4. It is equipped with a flexible lead and jack plug which can be plugged in to any of the sockets on the units. Each socket is shunted by an accurate wire-wound resistor which is one of three standard values, 15.4, 6.07 or 3.02 ohms. The resistance of the meter is 600 ohms so that a simple calculation shows that the multiplying factors are as follows:-

<u>Shunt</u>	<u>X Factor</u>	<u>Full scale Deflection</u>
15.4	40	10mA
6.07	100	25mA
3.02	200	50 mA

142. A list of nominal current readings for each jack is given in Table 4. The readings may differ slightly in individual receivers. The values given are actual indications on the meter in microamps - to obtain the current reading in milliamps multiply by the multiplication factor and divide by 1000: e.g. a current of 50 microamps through a 15.4 ohm shunt (multiplying factor 40) indicates an actual current of $\frac{50 \times 40}{1000} = 2\text{mA}$.

TABLE 4

Jack No.	TYPICAL METER READINGS				X Factor	Remarks
<u>Nominal reading</u>						
<u>RECEIVER UNIT</u>						
	N	X	Y	Z		
H.F.	120	120	120	120	200	
V1 V2	30	100	100	100	100	(Max. gain)
V3 V4 V5	110	40	40	40	100	
V7	180	180	180	180	100	
V8	50	50	50	50	100	(Min. gain)
V9	40	40	40	40	100	(Min. gain)
<u>DIODE RECEIVER</u>						
V2 V3	70				200	
V4 V5	100				200	
<u>FILTER INPUT UNIT</u>						
V1	60				40	
V2	110				100	
V3	20				40	(F.S.off)
V4	200				100	

17.
TABLE 4 (CONTD.)

<u>Jack No.</u>	<u>Nominal reading</u>	<u>X Factor</u>	<u>Remarks</u>
<u>FILTER STROBE UNIT</u>			
V ₁	15 to 30	40	(Depending on setting of "F.S. Position")
V ₂	75	100	
V ₃	170	100	
<u>STROBE GAIN CONTROL UNIT</u>			
V ₁	5	40	
V ₂	60	100	
V ₃	35	200	
<u>P.S. 3 and 4</u>			
V ₁	120	100	
<u>TIME BASE UNIT</u>			
	Main	Strobe	
V ₁	95	95	100
V ₃	60	115	100
V ₄	50	23	40
V ₅	60	100	40
V ₆	100	100	40
V ₇	60	60	40
V ₈	100	100	40
V ₉	100	100	40
V ₁₀	195	205	40
<u>A.V.C. UNIT</u>			
V ₁	30	100	
V ₃	100	100	
V ₄	45	100	
V ₅	40	100	
V ₆	5	100	(With A.V.C. operating)
<u>LITERATION UNIT</u>			
V ₁	20	40	
V ₂	60	40	
V ₃	60	40	
V ₄	150/120	40	(Cal. Pips/Sine wave)
<u>DIVIDER D.II</u>			
V ₁	95	100	
V ₂	140	40	
V ₃	130	40	
V ₄	140	40	

TABLE 4 (CONTD.)

<u>Jack No.</u>	<u>Nominal reading</u>	<u>X Factor</u>	<u>Remarks</u>
<u>DIVIDER D.II (CONTD.)</u>			
	Main	Strobe	
V ₅	105	100	
V ₆	120	40	
V ₈	105	100	
V ₉	185	40	
V ₁₀ V ₁₁	150	40	
V ₁₄	70/120	40	(Main/Strobe T.D.)
<u>DIVIDER D.III</u>			
V ₁	85	100	
V ₂	95	100	
V ₃	130	40	
V ₄	130	40	
V ₅	95	100	
V ₆	140	40	
V ₈	95	100	
V ₉	200	40	
V ₁₀	200	40	
V ₁₁	10	40	(Max Coarse Phase Shift)
V ₁₄	155	100	
V ₁₅	100	40	

TABLE I

[illegible]

TABLE 2

INTER UNIT CABLING

NO. ON BLOCK	COLOUR SMALL SLEEVE	COLOUR LARGE SLEEVE	TO	NO. ON BLOCK	COLOUR SMALL SLEEVE	COLOUR LARGE SLEEVE
203	Yellow	White		76	Black	Pink
202	White			72	White	
205	Blue	White		195	White	Blue
202	White			193	Orange	
211	White	White		197	Green	Blue
207	Black			196	Yellow	
212	Red	White		190	Green	Blue
207	Black			186	Orange	
218	White	Blue & White		199	Black	Blue
117	Green			198	Blue	
117	Orange	Orange		190	Green	Blue
EARTH PILLAR	Black			186	Orange	
105	Blue	Orange		188	White	Blue
104	Black			186	Orange	
155	Yellow	Red & Green		203	Yellow	White
156	White			202	White	
22	White	Green		67	Green	Red
20	Green			66	Yellow	
12	Green	Green & Orange		200	Orange	White
11	Yellow			202	White	
114	Yellow	Orange		194	Red	Blue
EARTH PILLAR	Black			193	Orange	
111	Black	Orange		73	Yellow	Pink
EARTH PILLAR	Black			72	White	
75	Blue	Pink		122	White	Brown
EARTH PILLAR	White			118	Black	
75	Blue	Red		158	Orange	Red & Green
72	White			156	White	
85 66	White Yellow			194 193	Red Orange	
NO. ON BLOCK	COLOUR SMALL SLEEVE	COLOUR LARGE SLEEVE	TO	TAPE COLOUR	PYE PLUG NO.	
17	Orange	Green		Orange & White	P.19	
15	White					
139	Green	Green & Orange		Blue & Red	P.18	
138	Yellow					
139	Green	Green & Yellow		Red	P.21	
138	Yellow					
206	Black	White		Orange & Blue	P.11	
204	Green					
216	Green	Blue & White		Green & Red	P.9	
214 Earth	Black Screw					
125	Orange	Brown		Orange & Green	P.10	
127	White					
125	Orange	Brown		Blue & Yellow	P.4	
127	White					
71	Red	Red		Yellow & Red	P.3	
72	White					
114	Yellow	Orange		White & Red	P.12	
EARTH PILLAR	Black					

TABLE 2 (CONTD.)

INTER UNIT CABLING

PYE PLUG NO	TAPE COLOUR	TO	TAPE COLOUR	PYE PLUG NO.
P.15	Orange		Orange	P.7
P.16	Black		Black	P.8
P.1	Blue		Blue	P.20
P.14	Green		Green	P.5
P.5	Green		Green	P.6
P.14	Green		Orange	P.15
P.22	Yellow		Yellow	P.23

NO. ON BLOCK	SLEEVE COLOUR	TO	NO. ON PHONE JACK
246	Green		1
245	Yellow		2
243	Red		3
244	White		4
248	Black		4A

TABLE 3

P.O. KEY CONNECTIONS

KEY NO. 198 (REMOTE/LOCAL/AUTO)				
NO. ON BLOCK	COLOUR	TO	LEAF NO. ON KEY	COLOUR OF LEAD
235	Orange		1	White
236	Red		2	Black
237	White		3	Red & Black
238	Yellow		5	Orange & Blue
239	Green		32	Slate
240	Blue		31	Green
241	Black		30	Orange & Red
221	Black		29	Blue & Red
222	Blue		28	Brown & Red
223	Green		27	Blue & White
224	Yellow		25	Red & White
225	White		24	Brown
226	Red		22	Red & Green
227	Orange		21	Red

KEY NO. 216 (LOCAL MANUAL CONTROL KEY)		
LEAF ON KEY NO. 198 (R.L.A.)	TO	LEAF ON KEY NO. 216 (L.M.)
29		1
32		6
5		2 & 5

KEY NO. 207 (CALIBRATION PIPS)			
NO. ON BLOCK	SLEEVE COLOUR	TO	LEAF ON KEY NO. 207 (C.A.L.PIPS)
228	Black		3, 8, 12 & 17
231	Yellow		9 & 10
232	White		2 & 11

KEY NO. 68(A) (FILTER STROBE)			
NO. ON BLOCK	SLEEVE COLOUR	TO	LEAF ON KEY NO. 68(A) (F.S.)
228	Black		2 & 5
229	Blue		3 & 6

KEY NO. 68 (D) (FILTER STROBE INSPECTION)			
NO. ON BLOCK	SLEEVE COLOUR	TO	LEAF ON KEY NO. 68(D) (F.S.I)
228	Black		2 & 5
230	Green		3 & 6

APPENDIX I

The Transitron

The 'Transitron' is a single valve circuit depending for its operation on the suppressor grid characteristics of a pentode. Its chief use is to generate a square wave from a synchronising pulse and in this respect the Transitron resembles the better known multivibrator.

Fig.1a shows the effect of variations of suppressor grid potential upon the anode and screen current of a pentode valve, the control grid being supposed to be connected to cathode, and the anode and screen voltages kept fixed. A fall in suppressor grid potential decreases the anode current and increases the screen current, the total valve current remaining approximately constant since this is determined by the control and screen grid potentials.

Suppose that the anode and screen are loaded by means of resistance R_1 and R_2 . Fig.1b illustrates typical potential levels to which the electrodes will adjust themselves when the suppressor is at cathode potential, and fig.1c the corresponding levels when the suppressor is below the anode current cut-off point. In fig.1b most of the valve current is passing to the anode so that there is a large drop of potential across the anode load; the screen current is small. In fig.1c the anode current is cut off by means of the suppressor grid so that the anode is at H.T. potential and the whole valve current flows to the screen. The screen potential thus adjusts itself to a very low value and the valve takes only a few milliamps of current, the behaviour of the first three electrodes being similar to that of a triode. During operation the transitron alternates between conditions (b) and (c).

Consider now the circuit of fig.1d and suppose a small negative synchronising pip fed through C_2 to the suppressor grid of the valve. Before the arrival of the pip the valve was in condition (b) with the suppressor at cathode potential, but the synchronising input takes it below cathode level and causes a decrease of anode current and an increase of screen current. The screen potential therefore falls and drives the suppressor grid further negative since they are coupled by means of C_1 . This causes a further increase of screen current and a cumulative action is set up which rapidly brings the valve into condition (c) with the anode current cut off and the screen at a low level. The suppressor grid is driven negative to earth by an amount equal to the fall in screen voltage. See fig.1e.

The screen current now discharges C_1 through R_3 and the potential on the suppressor grid rises towards earth. The discharge continues until the suppressor grid potential has risen sufficiently to allow the anode to take current; the screen current then falls allowing the screen potential to rise and carry the suppressor further towards cathode potential. This causes a further reduction in screen current and the action is cumulative. Most of the valve current now flows to the anode and so the anode and screen return to the levels shown in fig.1b. The suppressor grid is driven above earth potential by the sudden rise in screen voltage and the charge on C_1 then leaks away until the grid is again at earth level. The discharge of the condenser is partially effected by the flow of suppressor current. When the suppressor grid has returned to cathode level the cycle is complete and is repeated on the arrival of the next synchronising pip. Negative synchronising pulses arriving before the positive suppressor potential has been removed have no effect.

It will be seen that the anode waveform is a positive square wave and the screen a negative square wave. The width is determined by the discharge of C_1 through R_2 and R_3 and may be varied by adjustment of the suppressor grid leak R_3 .

In the circuit of fig.1f the width of the square wave output is varied by adjusting the potential at the end of the grid leak R_3 . The more positive this potential, the faster is the initial rate of discharge of C_1 so that the width is reduced by increasing the potential at the end of the leak. See fig.1g.

The transitron action fails if the anode load is so large as to bring the anode potential over the knee of the characteristics, for under these conditions the change in anode voltage affects the anode current and offsets the effect of the variation of suppressor potentials.

The stability of the Transitron may be improved by connecting a diode between suppressor grid and earth. With this arrangement it is also possible to synchronise the valve by means of positive pips as in fig.1j. For suppose the pentode removed, then the positive pip causes the diode to conduct and the condenser C_2 becomes negatively charged by the diode current. At the end of the positive pip the anode of the diode will be negative to earth since C_2 has now charged up. Thus the positive synchronising signal produces a waveform as shown in fig.1k at the anode of the diode. The negative part of this waveform serves to synchronise the transitron. The transitron cycle thus starts from the back edge of the positive synchronising pulse and the relation of the waveforms to the locking signal is shown in fig.1l.

APPENDIX II

The Blocking Oscillator

Consider the circuit of fig.2a. It will be seen that the anode and grid of valve V_1 are tightly coupled together by means of an iron-cored transformer, the polarity of which is arranged to give positive feedback to the valve.

Suppose the valve cut off by the negative charge on the grid condenser C. The charge leaks away through R and the grid drifts slowly towards cathode potential until eventually the valve starts to conduct. Anode current then flows through the primary of the transformer and the anode potential falls rapidly, an E.M.F. is also induced in the secondary and this carries the grid further positive. A cumulative action is set up which drives the grid well above cathode potential and the anode voltage falls to a low value. The effect of the inductance of the transformer windings is to make the growth of anode current slower than the fall of anode potential; the waveforms are shown in fig.2b. When the grid is positive to cathode, a large grid current flows and negative charge accumulates on the condenser C so that the potential at A falls.

After a time the anode current reaches its maximum value and stops increasing. But the E.M.F. induced in the secondary of the transformer is proportional to the rate of change of anode current so that the positive drive in the grid is reduced and the grid potential falls. This reduces the anode current and the anode potential rises rapidly; at the same time the grid is driven further negative. The valve is thus suddenly cut off so that the anode current falls almost instantaneously to zero and the resulting induced E.M.F. in the primary of the transformer carries the anode far above H.T. potential. At the same time the grid potential is carried below that of A. As the energy stored in the magnetic field of the transformer is dissipated the anode returns to H.T. potential and the grid to the potential at A.

The valve being cut off, the condenser is left with the negative charge accumulated during the conduction period and this leaks away through the resistance R. The discharge of the condenser is exponential and the waveforms at A is shown in fig.2c. The grid waveform is shown in fig.2d and it is seen that during most of the rest period, the grid is at the same potential as Point A. After a time determined by the time constant CR of the grid circuit and also by the extent to which A is initially driven negative, the grid approaches cathode potential and the valve again takes current. The cycle is then repeated.

In the circuit of fig. 2a the grid leak is taken to cathode so that the condenser discharges exponentially towards cathode potential. The valve does not start to draw current until the discharge is almost complete and the rate of rise of potential on the grid is then very slow. The recurrence frequency of the oscillator is therefore unstable. In fig.1e the grid leak is taken to a positive potential V and the potential at A rises exponentially towards this level. The grid reaches cathode potential when the process is only about one-third completed so that the rate of rise of potential at A is still rapid and the stability of the recurrence frequency is improved.

The rate of discharge of C is always proportional to the potential difference between its plates. If the potential V on the grid leak is increased, the discharge is speeded up so the recurrence frequency is increased. Thus a convenient frequency control is obtained by taking the grid leak to the slider of a potentiometer as in fig.2e.

The discharge time of C varies if the potential to which A is driven negative when V_1 conducts changes, is an important source of instability because variations in valve characteristics will affect the amount of grid current collected by the condenser and therefore the initial negative voltage at R. Variations of stray capacity on the grid of the valve, for example, offset the pulse width and so the amount of charge accumulated on the condenser. In order to stabilize the discharge period it is necessary to provide a means of regulating the potential through which C must discharge and to make it independent of the characteristics of V_1 .

If the cathode of V_1 is biased above earth level as in fig.2g, then a diode V_2 connected across the condenser as shown ensures that the rise of potential at A always starts from earth level. For although during the conduction period of V_1 the heavy grid current may carry A below earth, the diode V_2 returns A to earth as soon as the pulse has finished.

It is now necessary to stabilise the potential E at the cathode of V_1 . In the circuit of fig.2g, unless the current through the bleeder R_3 , R_2 is large compared with the valve current, the bias E on the cathode will vary if the valve current varies. For example, suppose that V_1 conducts for 3 microseconds in a period of 100 microseconds and that it takes 100 mA when it conducts. Then the mean current is 3 mA. Variations in pulse width or in the peak current will affect this mean current and cause a corresponding change in E. If the permissible variation of E is 1 volt and the possible variation of valve current is 1 mA., then R_2 must not exceed 1000 ohms. In order to bias the cathode to 60 volts above earth it would therefore be necessary to pass 60 mA. of current through this resistance and such large bleeder currents cannot be provided by a normal H.T. supply. A 'cathode follower' or 'regulating valve' V_3 is therefore introduced as in fig.2h and serves to stabilise the bias on V_2 . Since the output impedance of the cathode follower is only about 200 ohms, a variation of 1 mA. in the current taken by V_1 will cause only about 0.2 volt change in bias.

In the circuit of fig.2h the recurrence frequency is practically independent of valve characteristics. For the potential E on the cathode of V_1 is determined by the voltage on the grid of V_3 , that is by the potentiometer R_4 , R_5 . The time required for C to charge up to this voltage is determined by C, the grid leak R_1 and the voltage V determined by P_1 and R_6 . These components alone determine the recurrence frequency and can be made of high quality materials. Wire wound resistor and silvered mica condensers are suitable.

APPENDIX III

Delay Network

A delay network may be regarded as an artificial length of transmission line. An electromagnetic wave is propagated down a transmission line with a definite velocity V, almost exactly equal to the velocity of light. Suppose that at time $t = 0$, a positive voltage is suddenly applied to the end of an infinite line as in fig.3a. This rise of voltage travels down the line and reaches a point at distance x from the end at time $t = x/V$. If the line is of infinite length the process will continue indefinitely.

If at any point P along the infinite line a measurement was made of the instantaneous current and voltage as in fig. 3b, it would be possible to calculate the ratio $E/i = Z$. This ratio represents the effective impedance of the piece of line to the right of P. Suppose now that the line was cut at P and the left-hand portion terminated by an impedance equal to Z. Then the current and voltage at P would be related in just the same way as if the transmission line continued past P and so the waveforms to the left of P are unaffected. Z is called the characteristic impedance of the transmission line, and a piece of line terminated by an impedance Z behaves as though it was of infinite length. Z is purely resistive.

The behaviour of a transmission line is due to the fact that the wires possess distributed inductance and capacity. If L is the inductance per unit length and C the capacity per unit length the impedance is given by $Z = \sqrt{L/C}$ which has the dimensions of a pure resistance.

An artificial line may be produced as in fig. 3c by means of lumped inductances and capacities. If we consider first an infinite chain then the behaviour is similar to that of an infinite line, that is, it transmits applied waveforms with a definite velocity. The velocity must now be expressed in 'elements per second' instead of 'meters per second' in accordance with the fact that one element represents a short piece of line. The impedance R is still given by $R = \sqrt{L/C}$ obtained by substituting 'inductance per element' and 'capacity per element' for inductance per unit length and 'capacity per unit length' in the previous formula.

Suppose that it is required to delay a pulse. The pulse may be fed in to one end of a delay network which is terminated at the other end by its characteristic impedance. The waveform travels through the elements and after a definite time arrives at the other end where its energy is completely absorbed by the terminating impedance which simulates a continuation of the network. A delayed but undistorted pulse is therefore produced at this point. The delay, of course depends on the number of elements in the network and on the delay produced by each element.

Consider a typical section element. The succeeding elements may be replaced by the characteristic impedance R of the network as in fig. 3f. It is clear that this element will attenuate high frequency components of the applied waveform because C prevents a small impedance at these frequencies. The impedance of L and C becomes equal at a frequency given by $2\pi f_0 = 1/\sqrt{LC}$ and at higher frequencies the impedance of C is small compared with that of L, so that the element attenuates the applied waveform. The periodic time t_0 corresponding to a frequency f_0 is $t_0 = 1/f_0 = 1/2\pi f_0 = 1/2\pi \cdot 1/\sqrt{LC}$ and this is the time required for the current through L to appreciably affect the charge on C. Thus if the waveform applied to the network rises instantaneously as in fig. 3g, the output waveform will require about t_0 seconds in which to rise because this is the time required to change the charge on the condenser in the network. The values of inductance and capacity in a delay network must be chosen so as to permit the required rate of rise of the outcoming pulse.

The delay of the element may also be estimated. The back E.M.F. induced in the inductance opposes any sudden rate of change of current and therefore any sudden change of voltage across R. The time required for a major change in the current through L as a result of a change in the voltage applied at A is L/R seconds. Thus if the potential at A rises suddenly we expect a delay of about L/R seconds before the rise of potential at C is complete. It can be shown that the element produces a delay of exactly L/R seconds.

Collecting the previous results:-

Network impedance	$R = \sqrt{L/C}$
Delay per element	$= L/R \text{ secs} = \sqrt{LC} \text{ secs}$
Time of rise of output pulse	$= 2\pi/\sqrt{LC} = t_0 \text{ secs.}$

A delay network consists of an aggregate of elements such as those of fig. 3f. In practice these are more conveniently wound as in fig. 3j, the two end inductances being L/2.

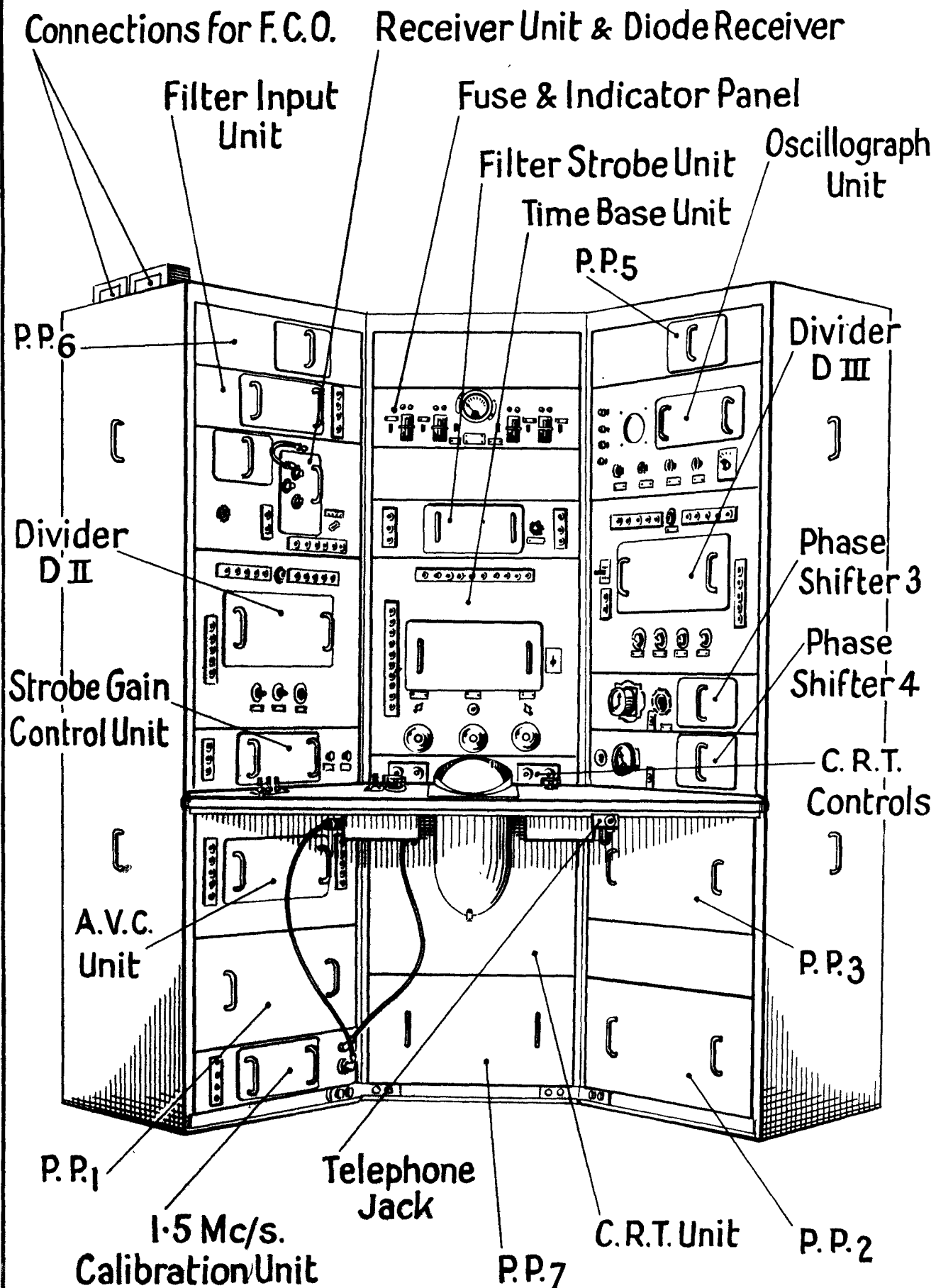
Reflections

Suppose that a delay network is short circuited at one end B as in fig. 3l, and that the potential at the other end A is suddenly raised to V volts above earth. The rise of potential is propagated along the network in the usual way and if there are n elements reaches B after nT seconds, T being the delay produced by each element. Since the network is short circuited at B no potential difference can exist at this point. When the positive going wavefront reaches B it is immediately reflected and inverted and the reflected wavefront starts to travel along the network towards A. The reflected wave is negative going and of the same amplitude as the incident; the two waveforms therefore cancel out at B as is required. The negative going waveform leaves B at time nT and arrives at A after a further nT seconds, just 2nT seconds after the rise of potential at B. The waveform at A is thus a positive square wave of V volts amplitude and 2nT seconds duration. The potential at B is always zero and at intermediate points the applied and reflected waveforms combine to produce a positive square wave of width less than 2nT seconds. It has been assumed that the returning wavefront suffers no further reflections at A; this is the case if the network is terminated at A by its characteristic impedance.

The reflection of a waveform by a short circuited network or piece of transmission line is similar to the reflection of a ray of light at the surface of a mirror. If P (fig. 3m) is a source of light in front of a mirror then a ray such as PR is reflected at R and continues along RS. The ray PN which meets the mirror at right-angles is reflected back along NP. All the reflected rays appear to diverge from a point Q behind the mirror, P and Q are at equal distances from the reflector and Q is called the image of P. Thus an observer in front of the mirror sees what appears to be a second source of light at Q, the light reflected from the mirror seeming to be radiated from the imaginary source.

The method of images may also be used to determine the behaviour of a short circuited line. Imagine the line continued past B to C and that the sections AB and BC both contain the same number of elements. If at the instant $t = 0$ the potential at A is suddenly raised to V volts above earth and that at C lowered to V volts below earth, then a positive going wavefront will travel from A towards C and a negative going wavefront from C towards A. These two waveforms both arrive at B at the same instant nT seconds after the start of the wave motion and cancel out. At points in AB the negative going wavefront propagated from C behaves in just the same way as that reflected from B in the circuit of fig.3.1 so that the waveforms at points in AB are just the same as in the previous case of a short circuited network.

It is seen that a short circuited delay network can be used to produce a pulse of width determined by the constants of the network. A practical circuit is shown in fig.3.2. The network is placed in the anode of a valve and a wide negative square wave is applied to the grid. The front edge PQ of the grid waveform causes a rise AB of anode potential; this is propagated down the network and the reflected wavefront brings the anode potential down along CD. The width of the pulse ABCD is $2nT$, the time taken for a wavefront to cross the network twice. The back edge RS of the grid waveform causes a fall EF in anode potential and $2nT$ seconds later the reflected wavefront returns the anode to its normal level at H. It is seen that the front edge of the positive pulse ABCD coincides with the front edge of the grid waveform but that the width of the pulse depends solely on the constants of the network.



GENERAL VIEW

FIG. I

FIG. I

FIG. 2

A. Strobe
Position
(C39 of Time Base)

B. Strobe
Position Fine
(C40 of Time Base)

Filter Strobe
on/off Switch

Filter Strobe
Inspection
Switch

Calibration Unit Switch

P.S5
Control

F. C.O. Manual Control Key
CONTROL DESK

P.S4 Control

Preset Time Base
Controls
Inside Cover

C. Strobe
Position Fine
(C46 of Time Base)

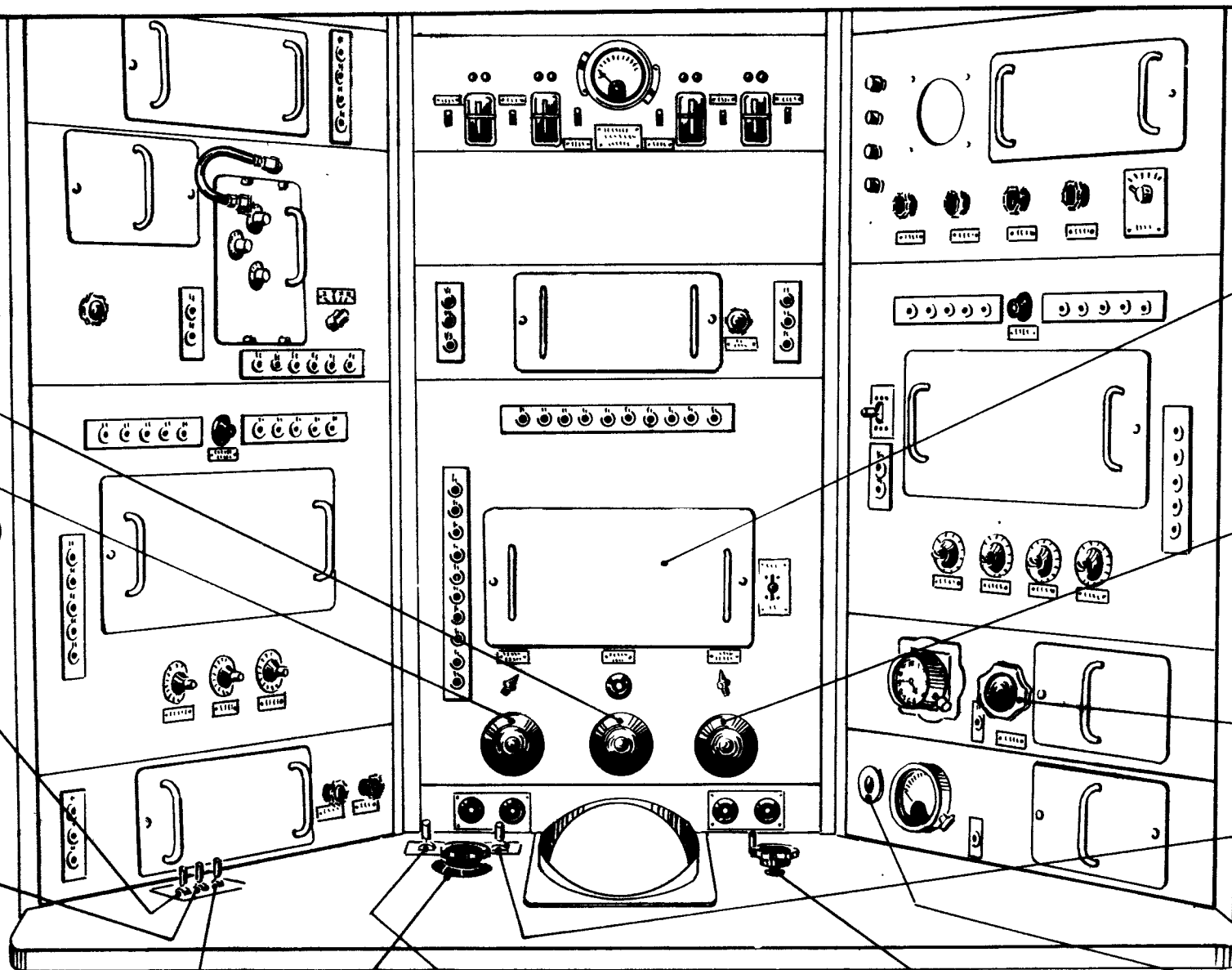
P.S3 Control

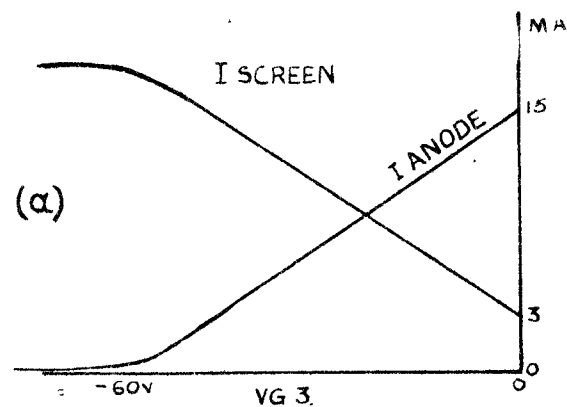
Remote-Local-Auto
Key

Meter Socket

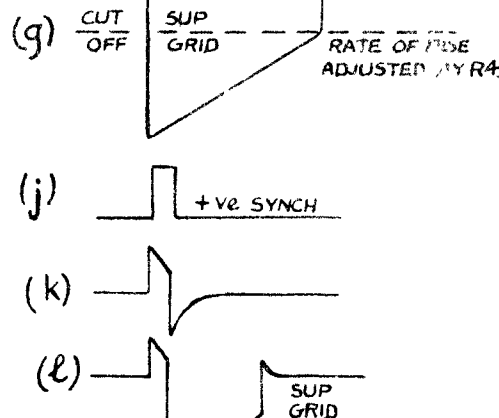
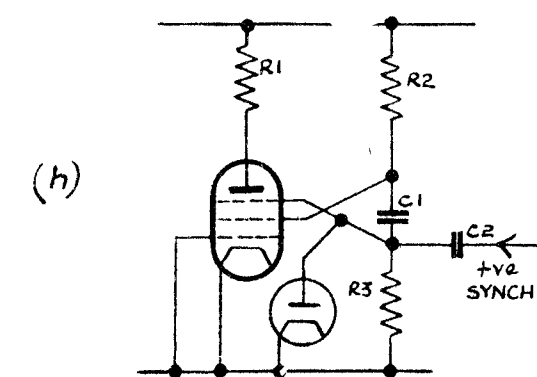
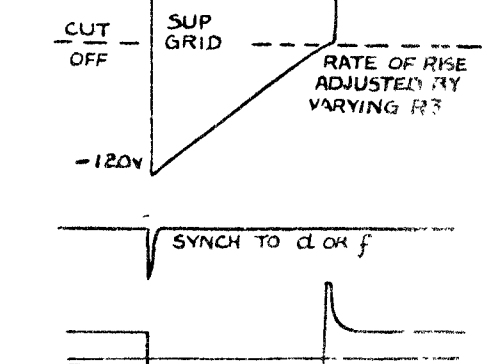
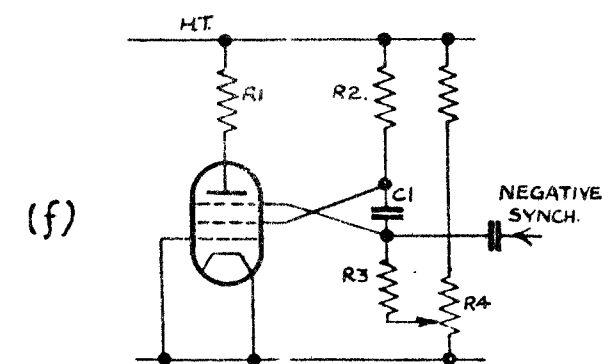
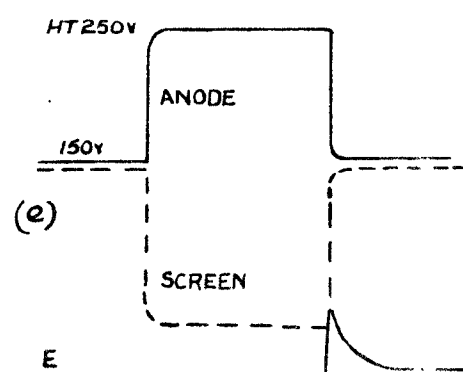
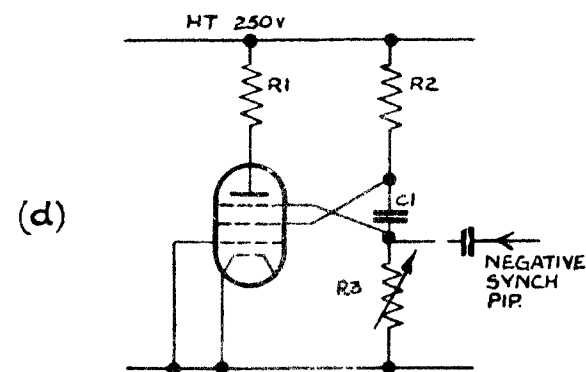
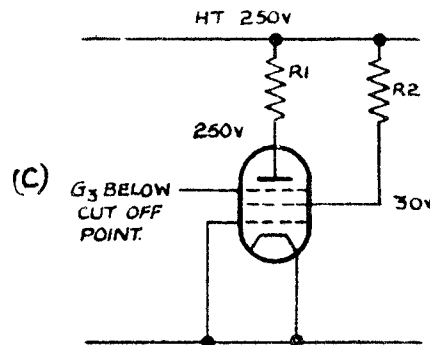
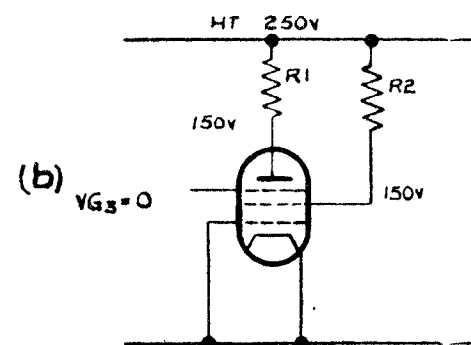
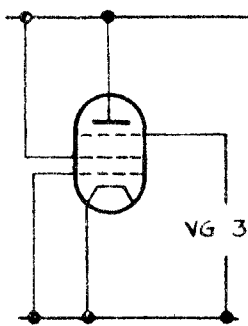
S.D.0295 (I), CHAP. 12.

FIG. 2



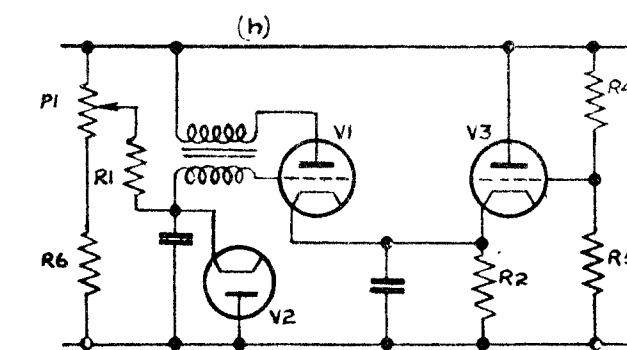
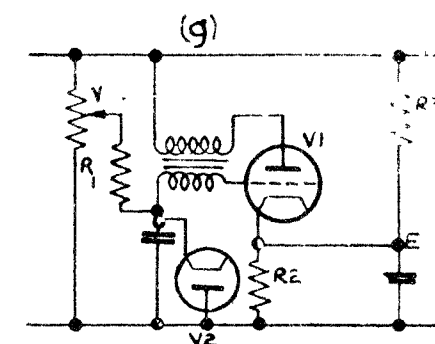
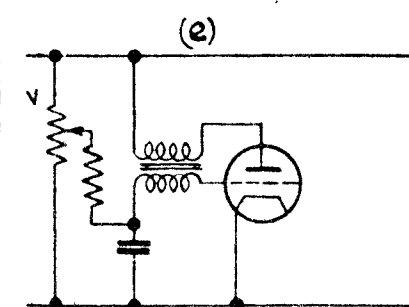
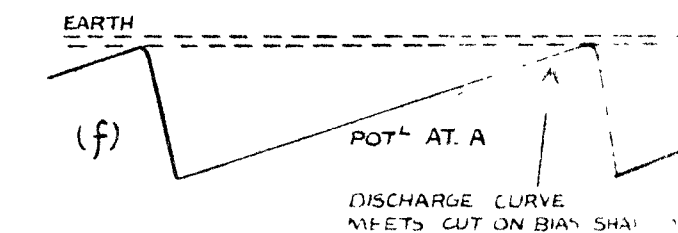
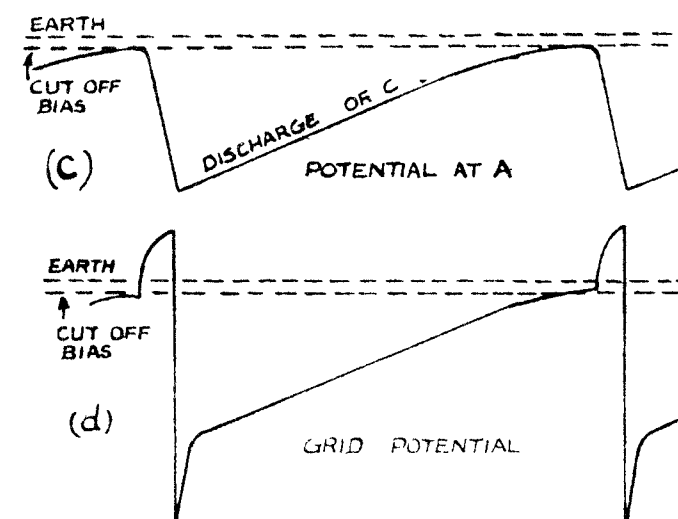
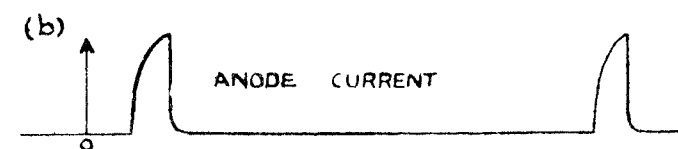
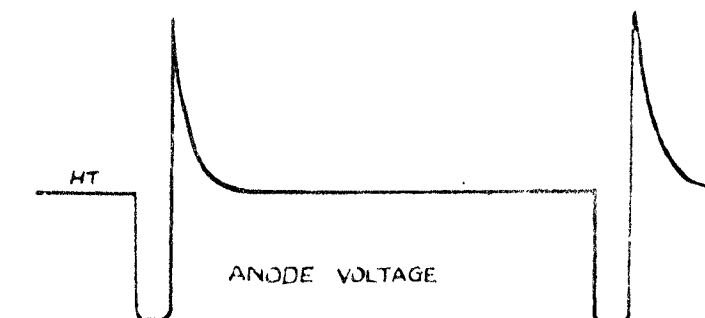
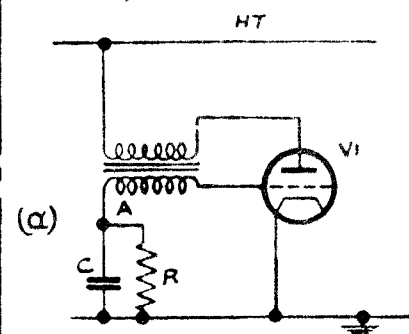


$$V_A = V_{G2} = 150V$$



TRANSITRON WAVEFORMS.

T.R.E. SK A 5687.



THE BLOCKING OSCILLATOR

T.R.E. SK.A 5697

FIG. 3

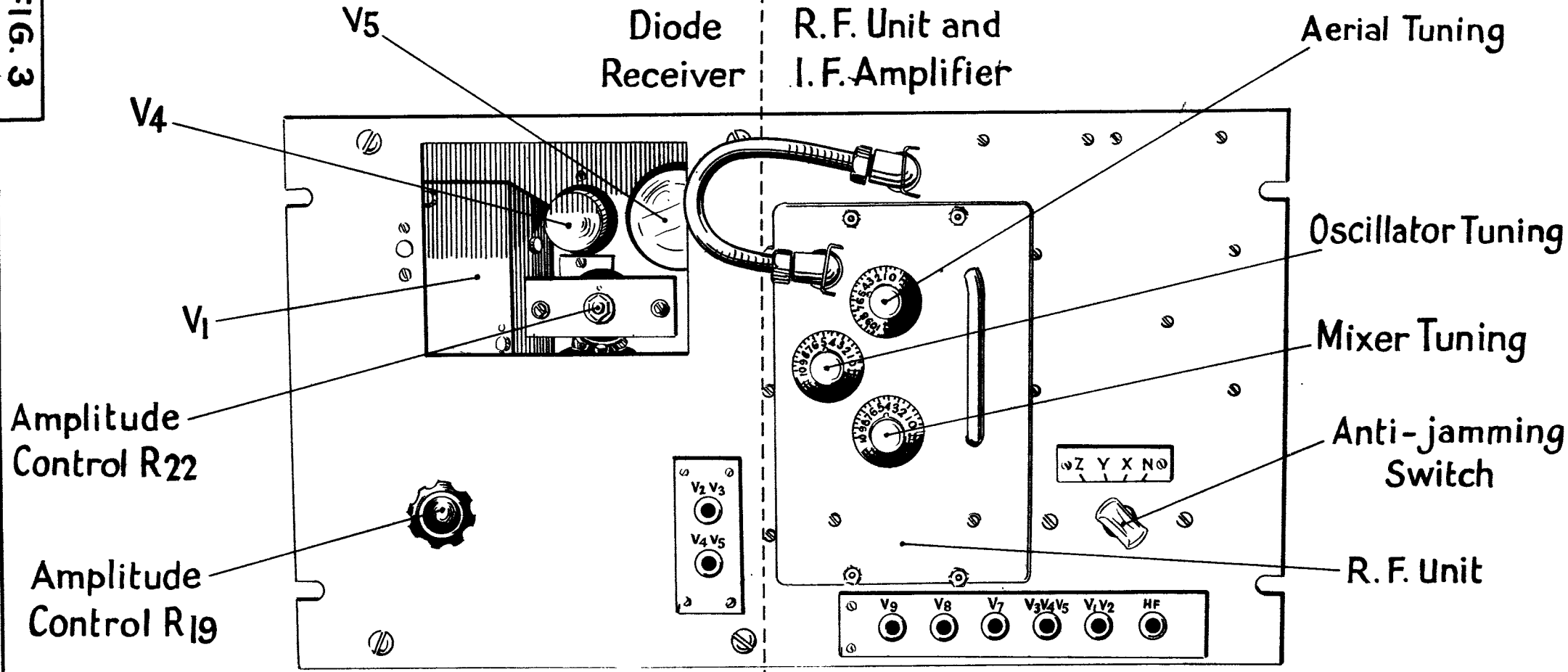
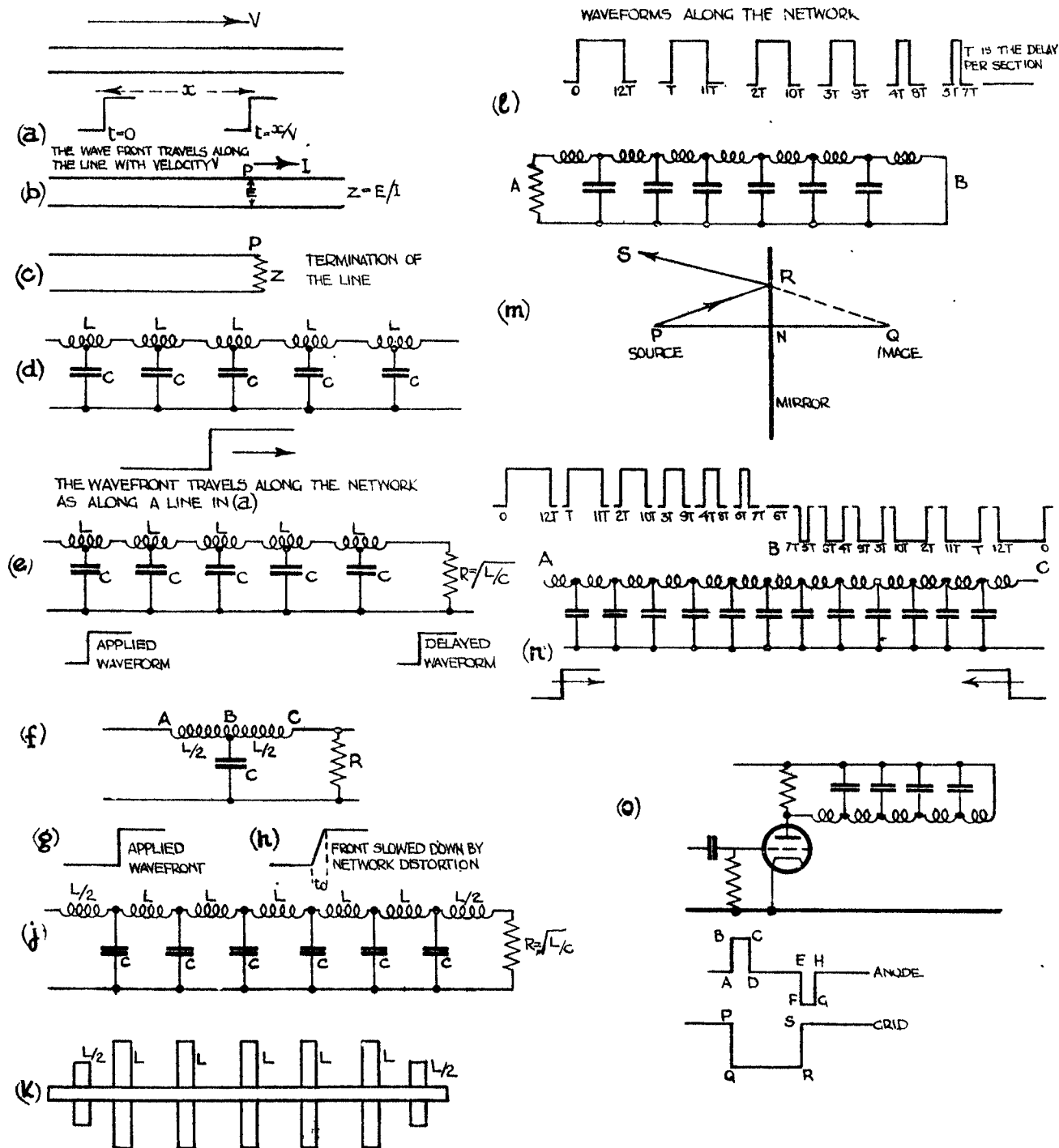


FIG. 3

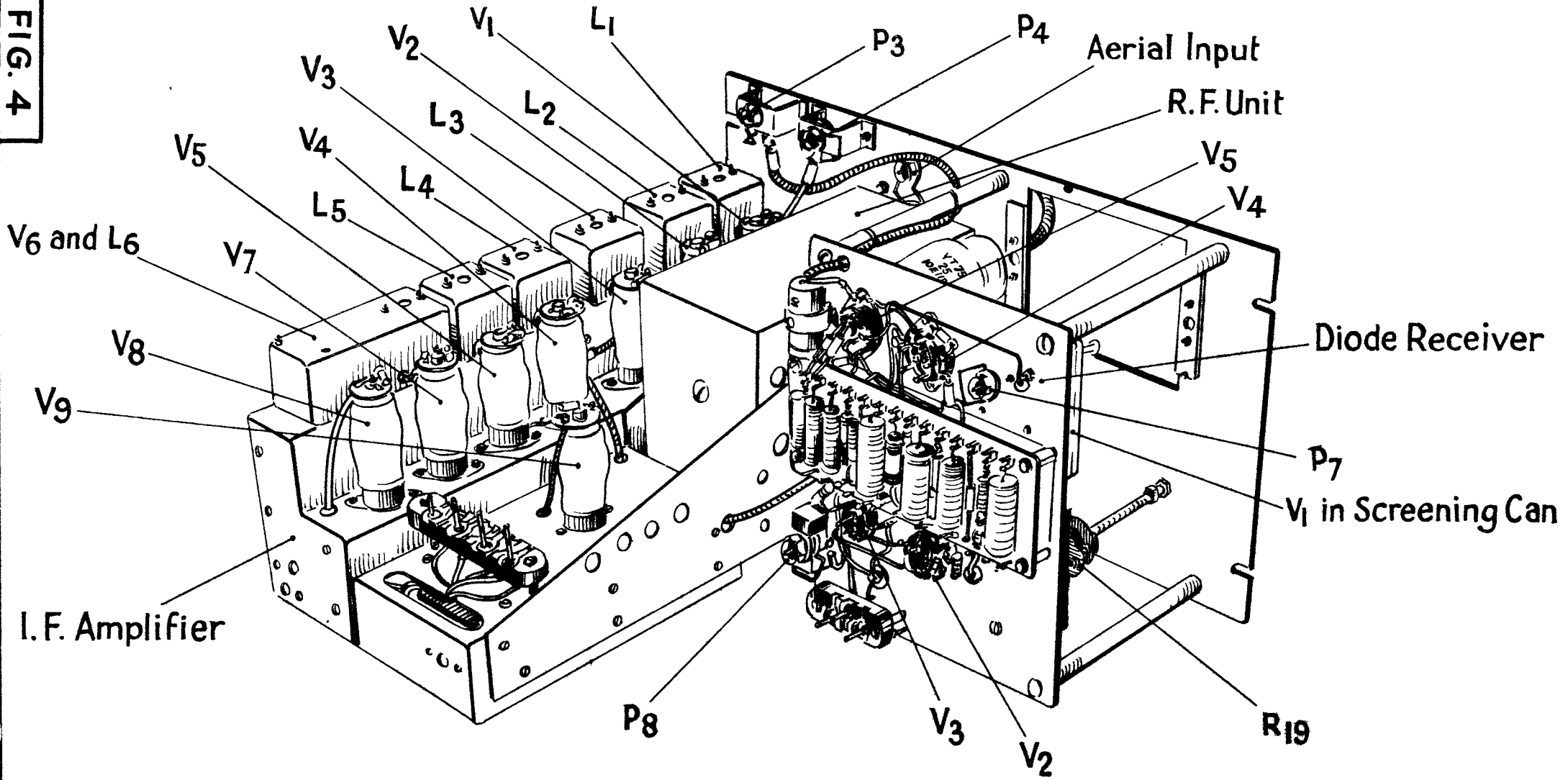
RECEIVER UNIT AND DIODE RECEIVER
Front View



DELAY NETWORK.

53126

FIG. 4

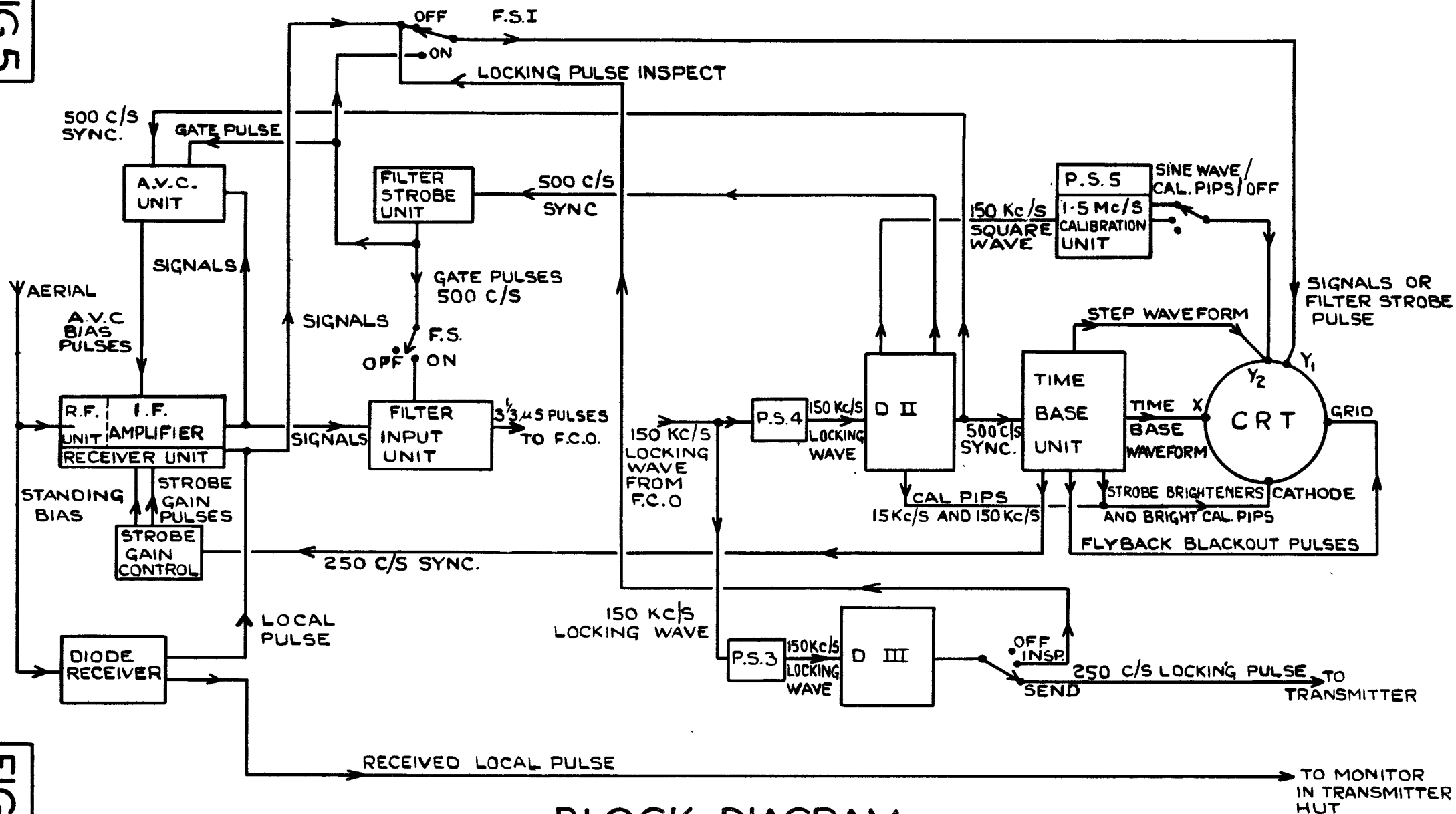


RECEIVER UNIT AND DIODE RECEIVER
Rear View

FIG. 4

S.D. 0295 (I), CHAP. 12.

FIG.5



BLOCK DIAGRAM

FIG.5

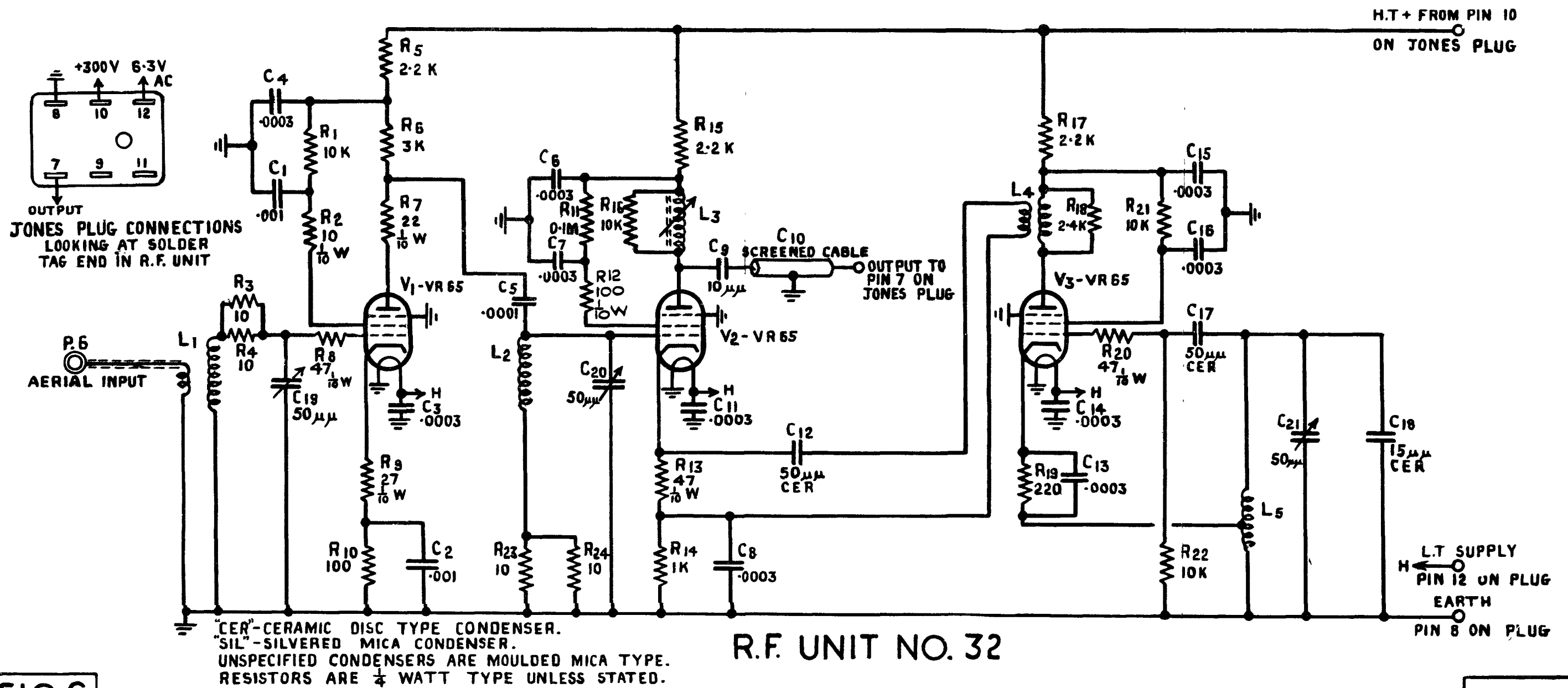
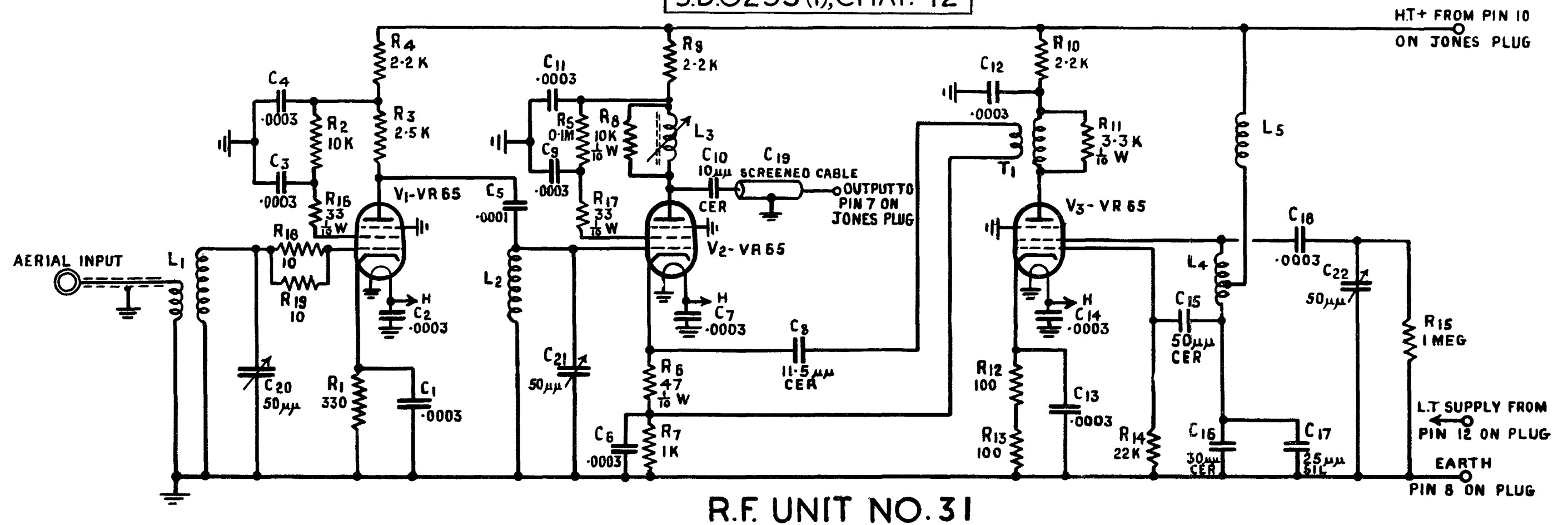
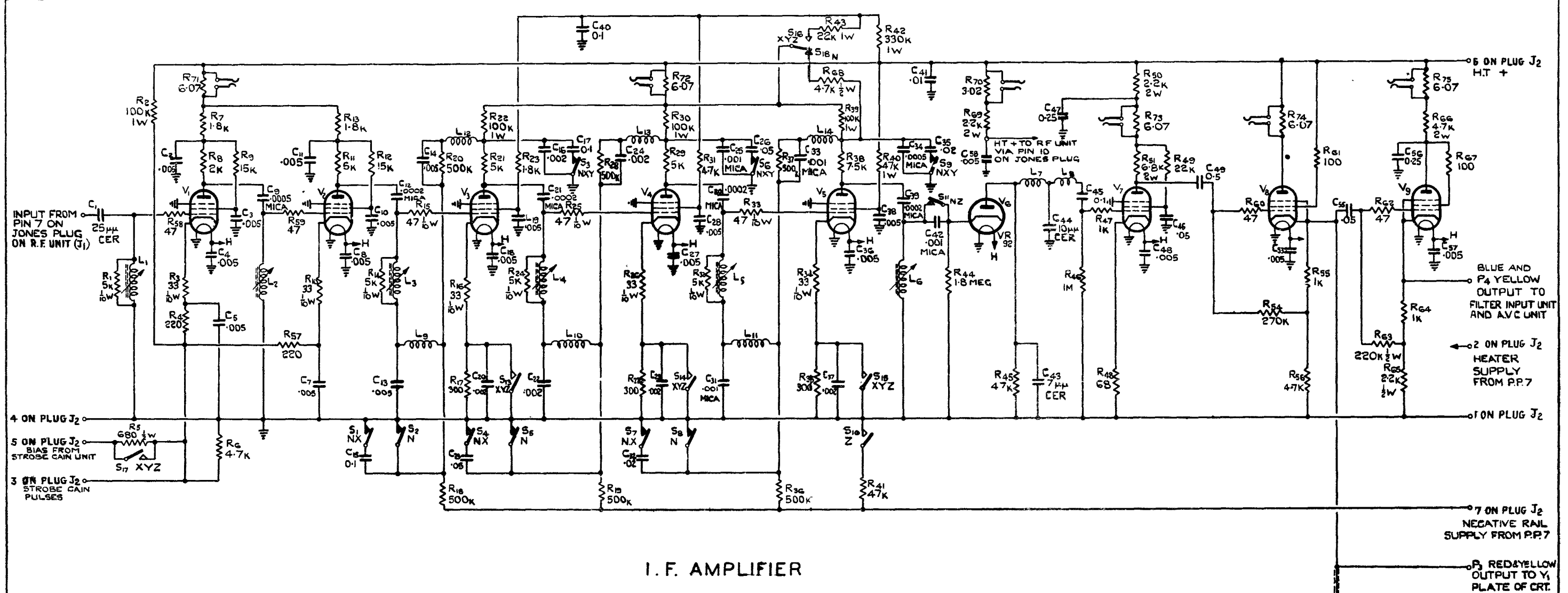


FIG. 6

FIG. 6

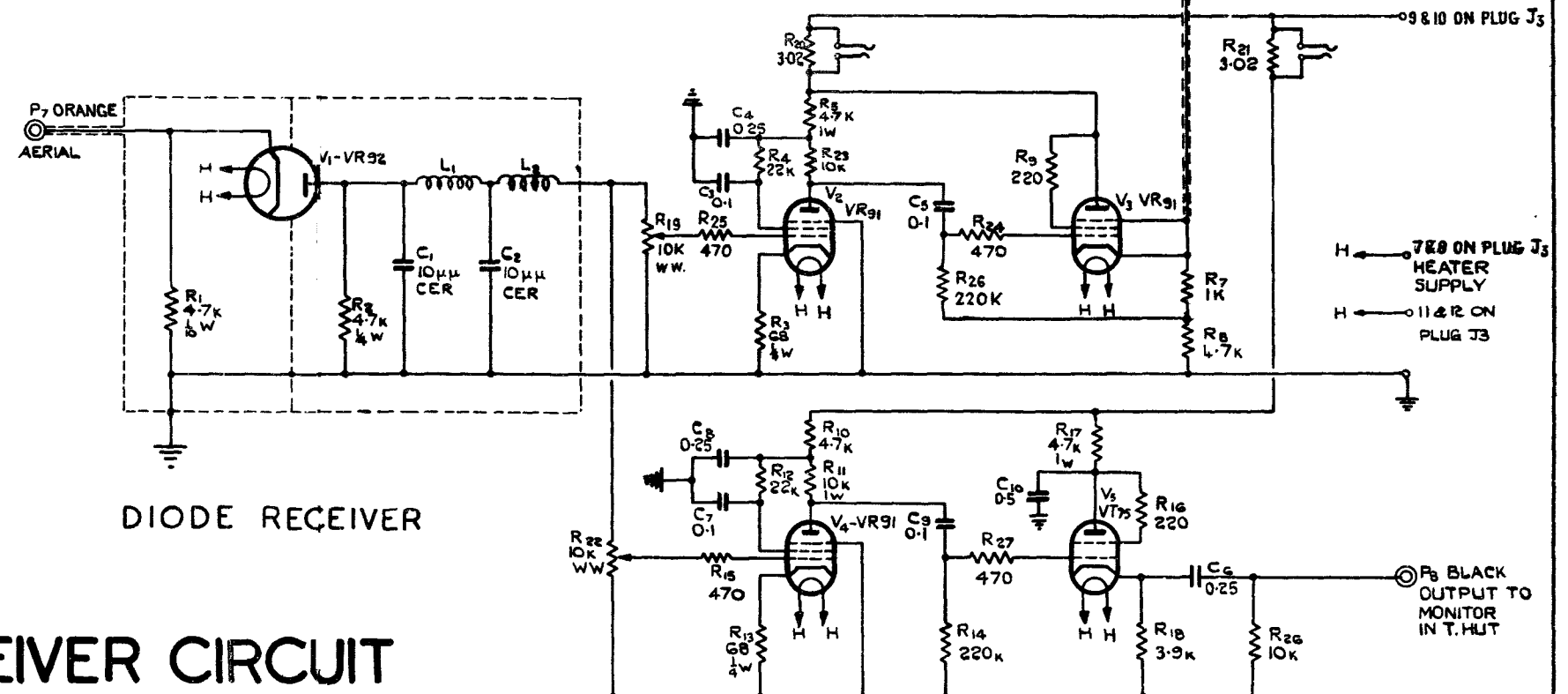


NOTES:

ALL VALVES TYPE V.R.65 UNLESS OTHERWISE STATED
RESISTORS 1/2 WATT TYPE UNLESS OTHERWISE STATED
"CER" CERAMIC DISC TYPE CONDENSER
"MICA" MOULDED MICA TYPE CONDENSER
"W.W" WIRE-WOUND POTENTIOMETER

ANTI - JAMMING SWITCH CONTACTS
S₁ TO S₁₆ ARE SHOWN IN THE "NORMAL" POSITION
AND THE POSITIONS IN WHICH EACH ARE CLOSED
ARE ALSO MARKED ON THE DIAGRAM BY THE
LETTERS "N, X, Y, Z".

WAFER	2			3			4			5	6	7	8	9	10
SWITCH	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈	S ₉	S ₁₀	S ₁₁	S ₁₂	S ₁₃	S ₁₄	S ₁₅
N	C	C	C	C	C	C	C	C	C	C	O	O	O	O	C
X	C	C	C	C	O	C	O	C	O	O	C	C	C	C	O
Y	O	C	O	O	O	C	O	O	C	O	O	C	C	C	O
Z	O	O	O	O	O	O	O	O	C	C	C	C	C	C	O



I.F. AMPLIFIER & DIODE RECEIVER CIRCUIT

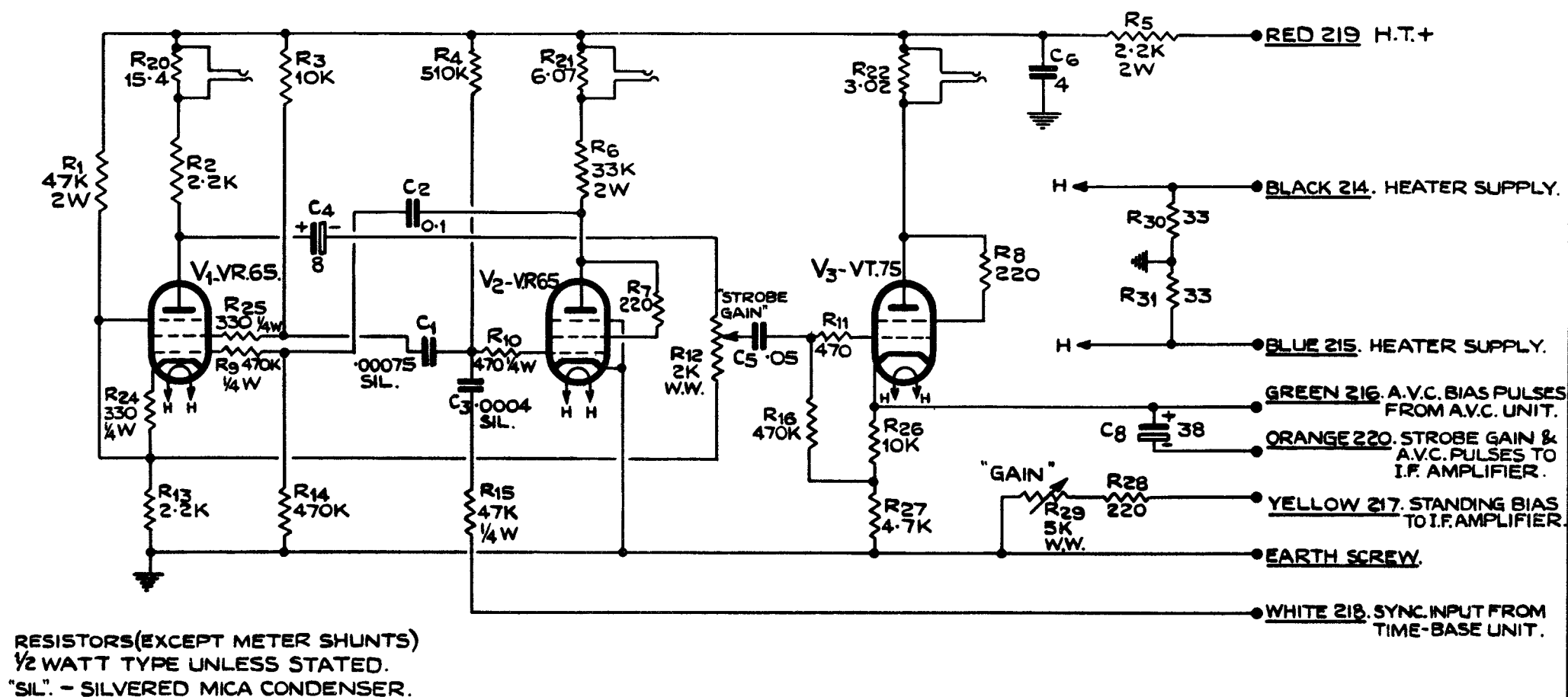


FIG.8. STROBE GAIN CONTROL UNIT - CIRCUIT.

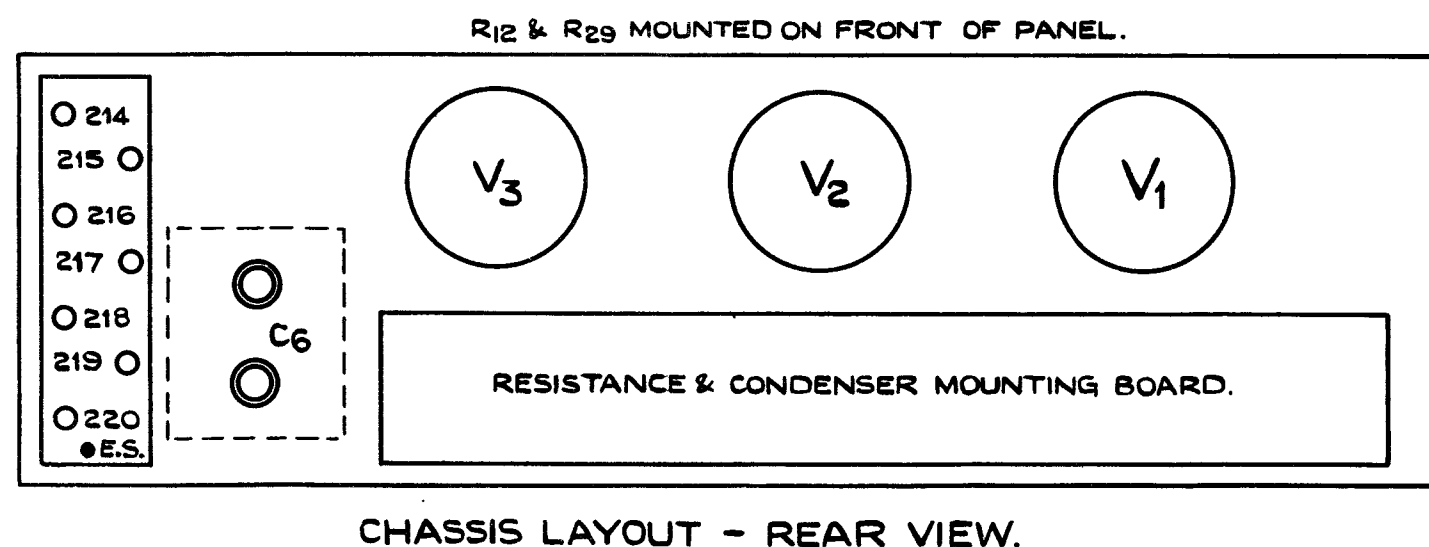


FIG.10. STROBE GAIN CONTROL UNIT - LAYOUT.

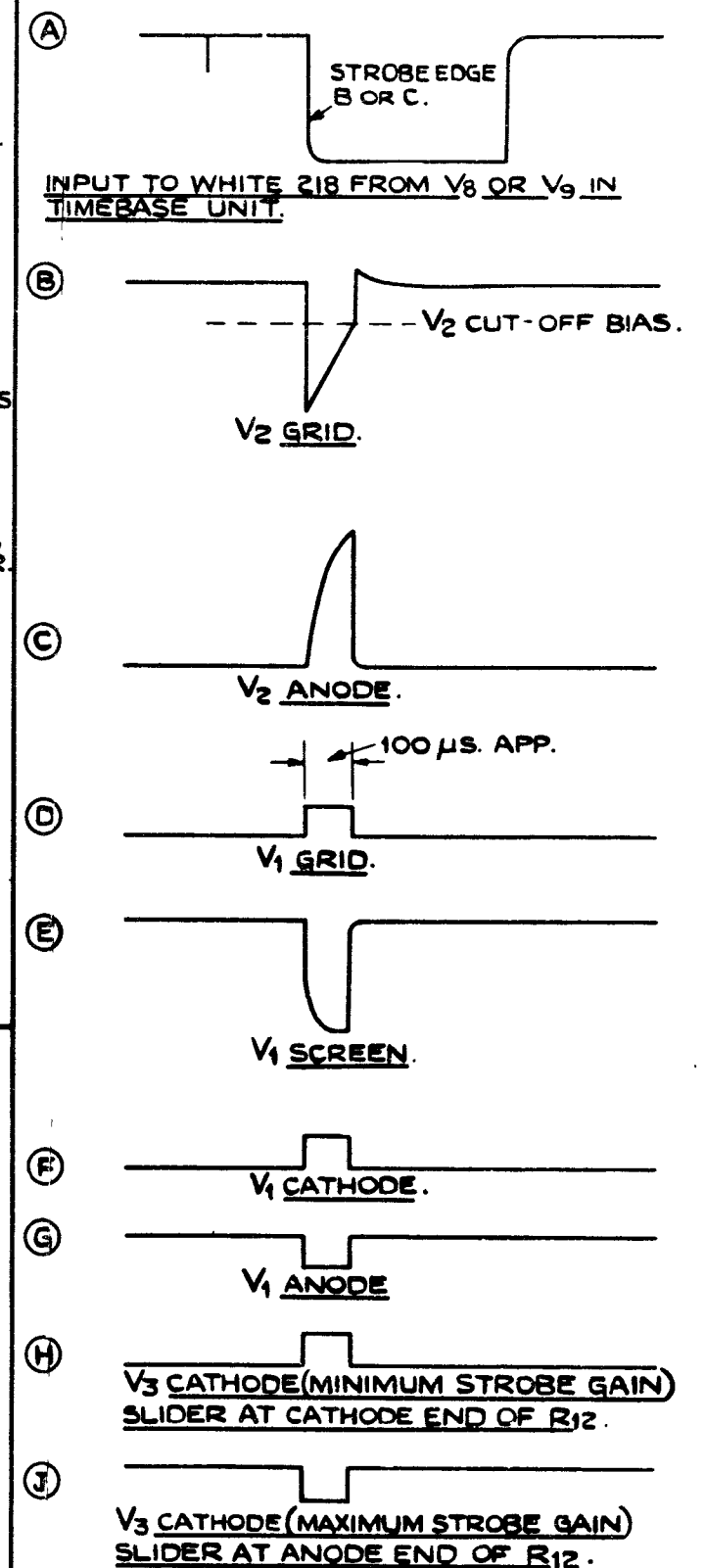
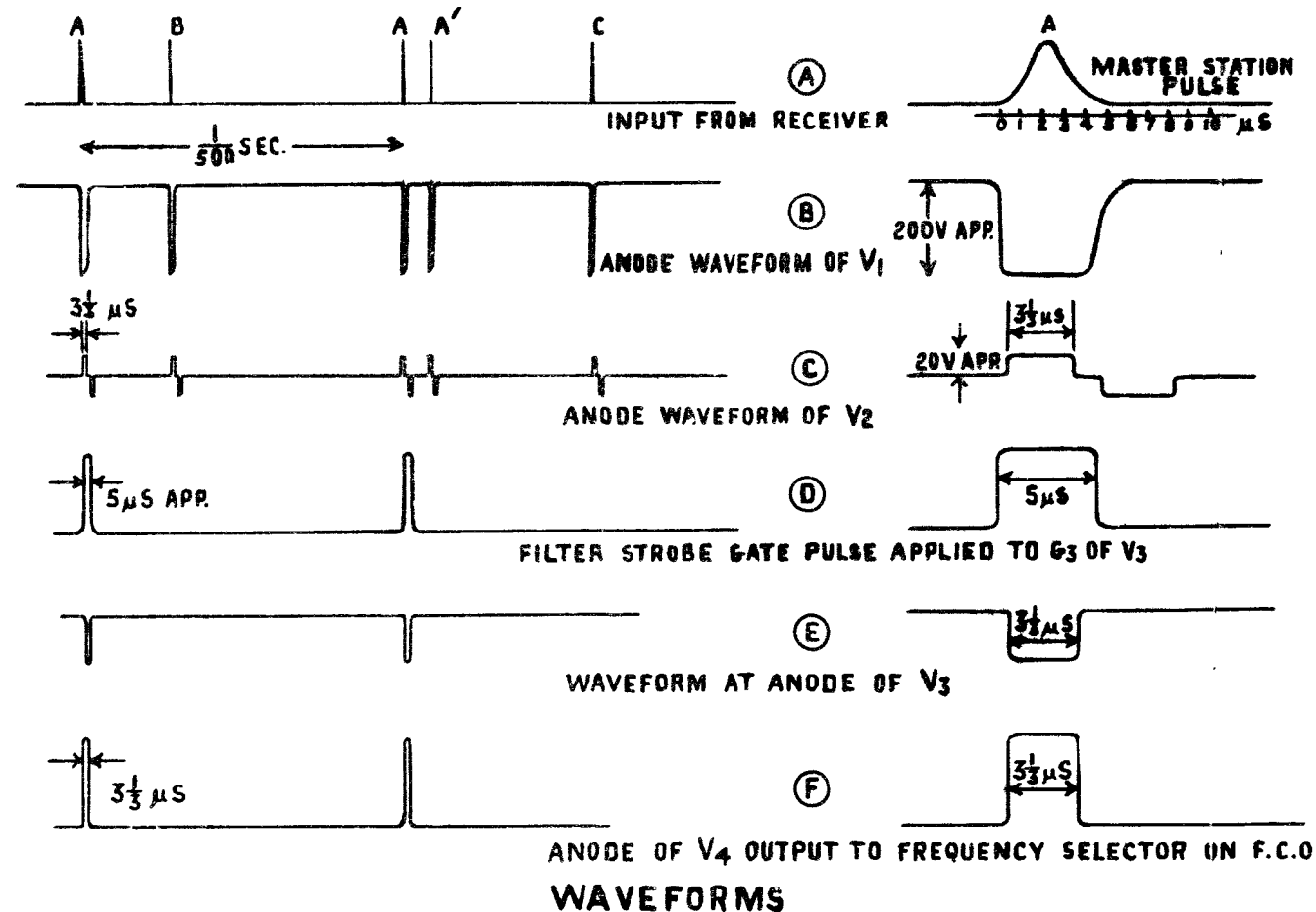
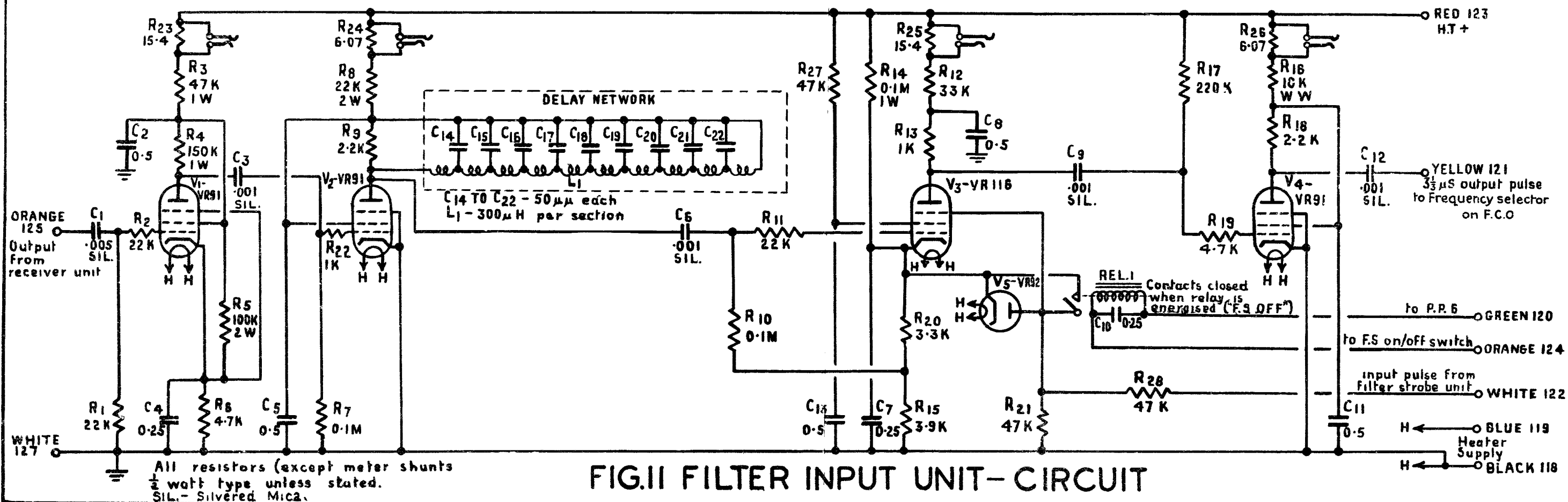


FIG.9. STROBE GAIN CONTROL UNIT - WAVEFORMS.



NOTE. Waveforms on the right are expanded views of pictures on left

FIG.I2 FILTER INPUT UNIT WAVEFORMS

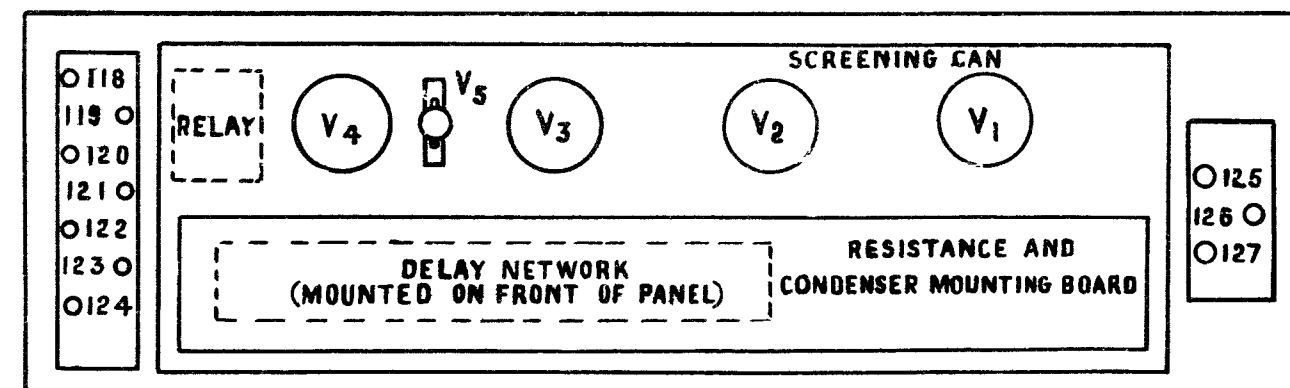


FIG.I3 FILTER INPUT LAYOUT

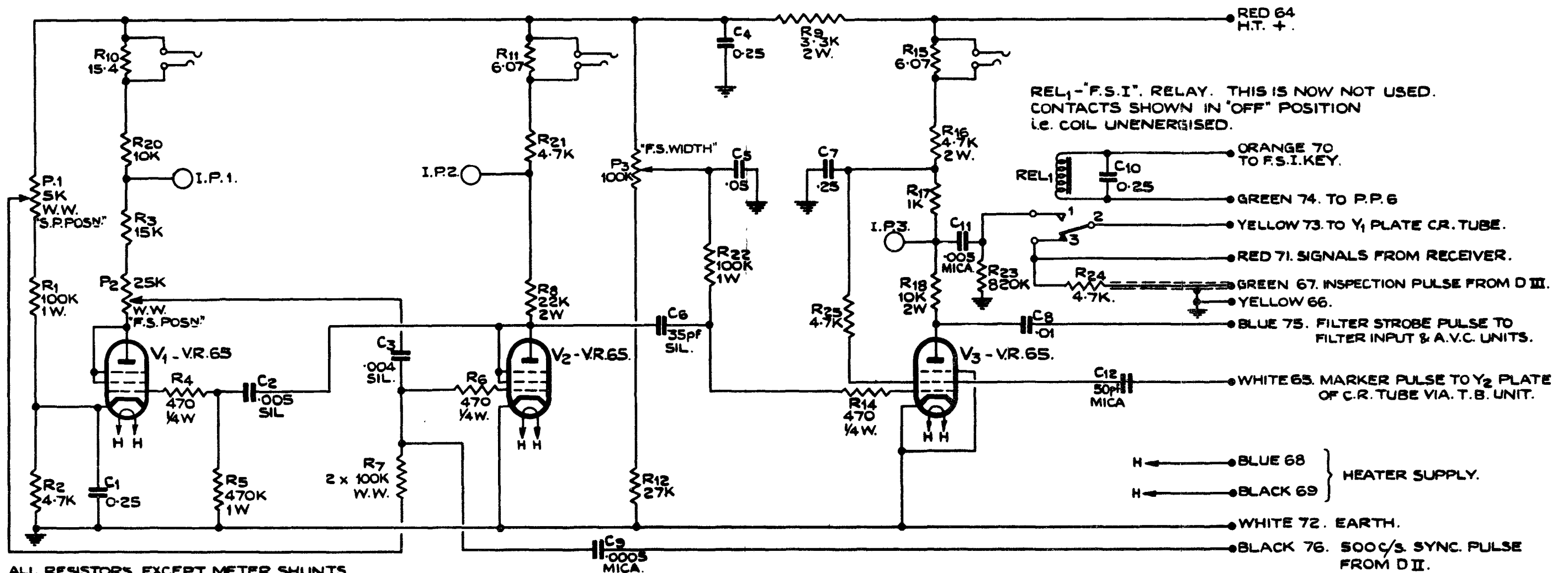


FIG. 14. FILTER STROBE UNIT - CIRCUIT.

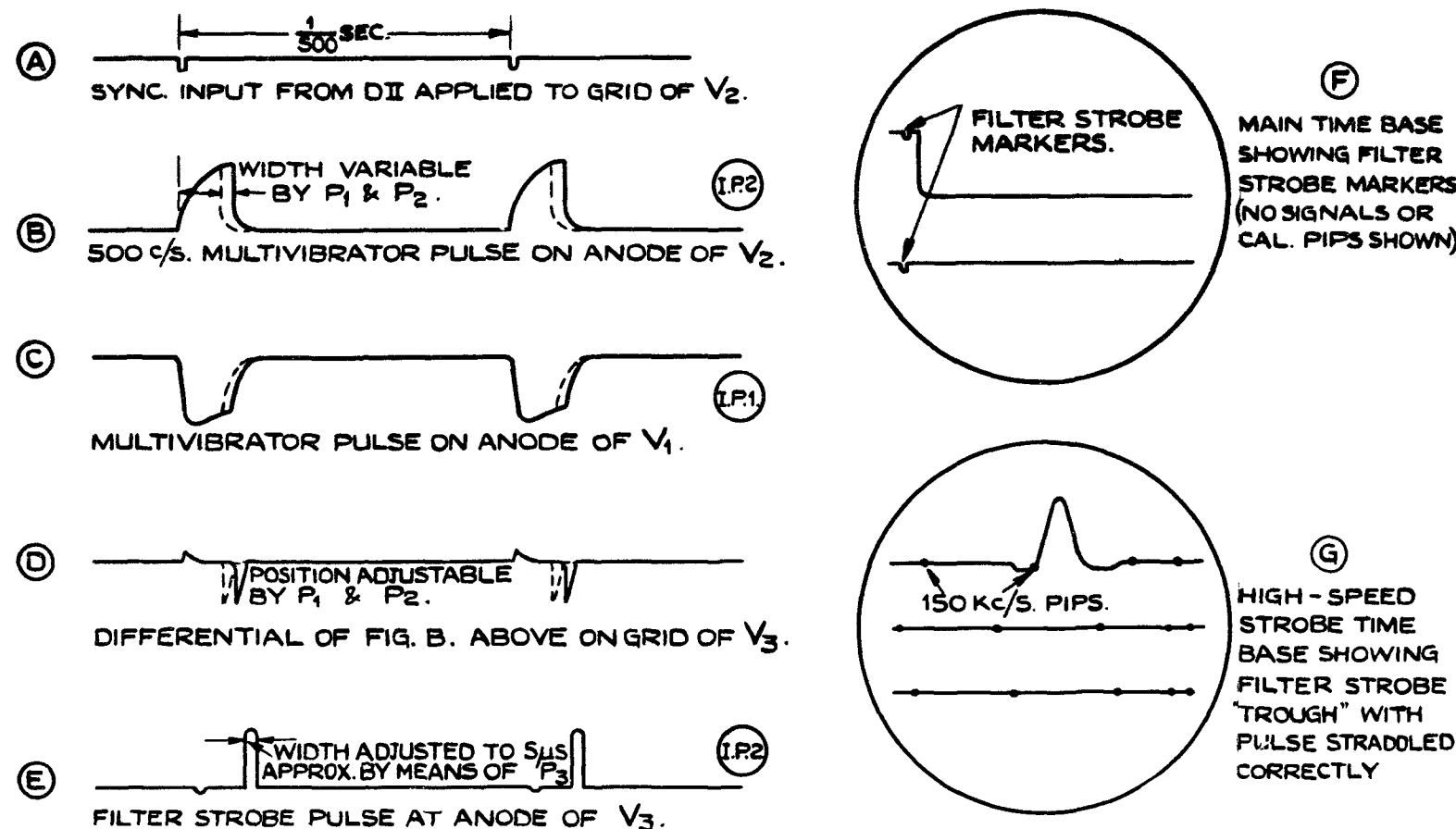


FIG. 14, 15 & 16

FIG 15 - FILTER STROBE UNIT - WAVEFORMS.

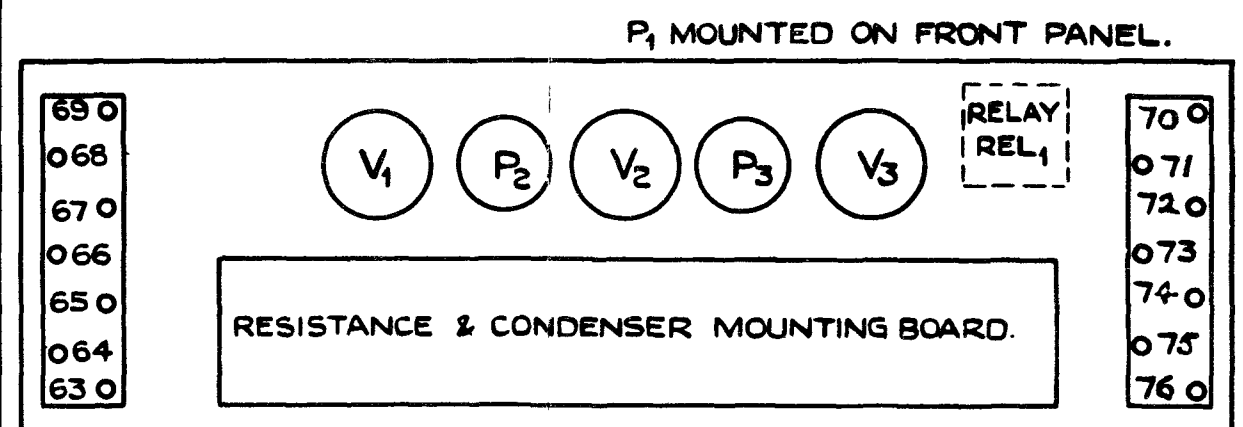


FIG. 16. FILTER STROBE UNIT - LAYOUT. (REAR VIEW)

FIG. 14, 15 & 16.

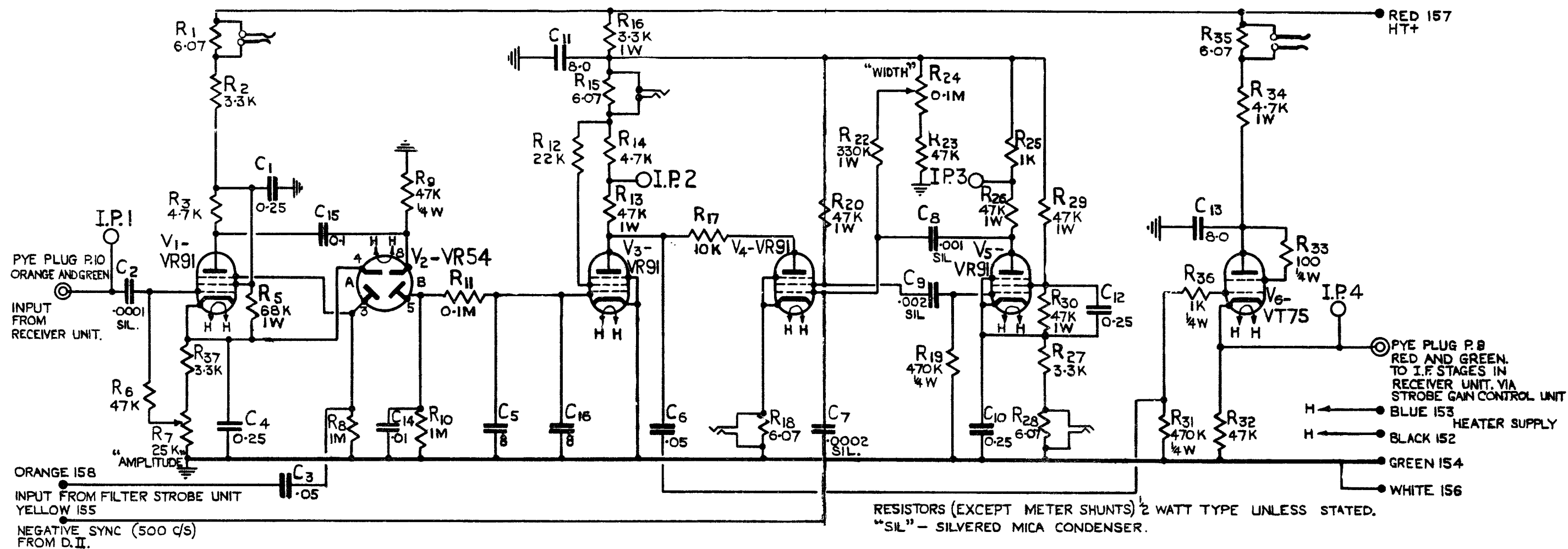


FIG. 17 A.V.C. UNIT CIRCUIT

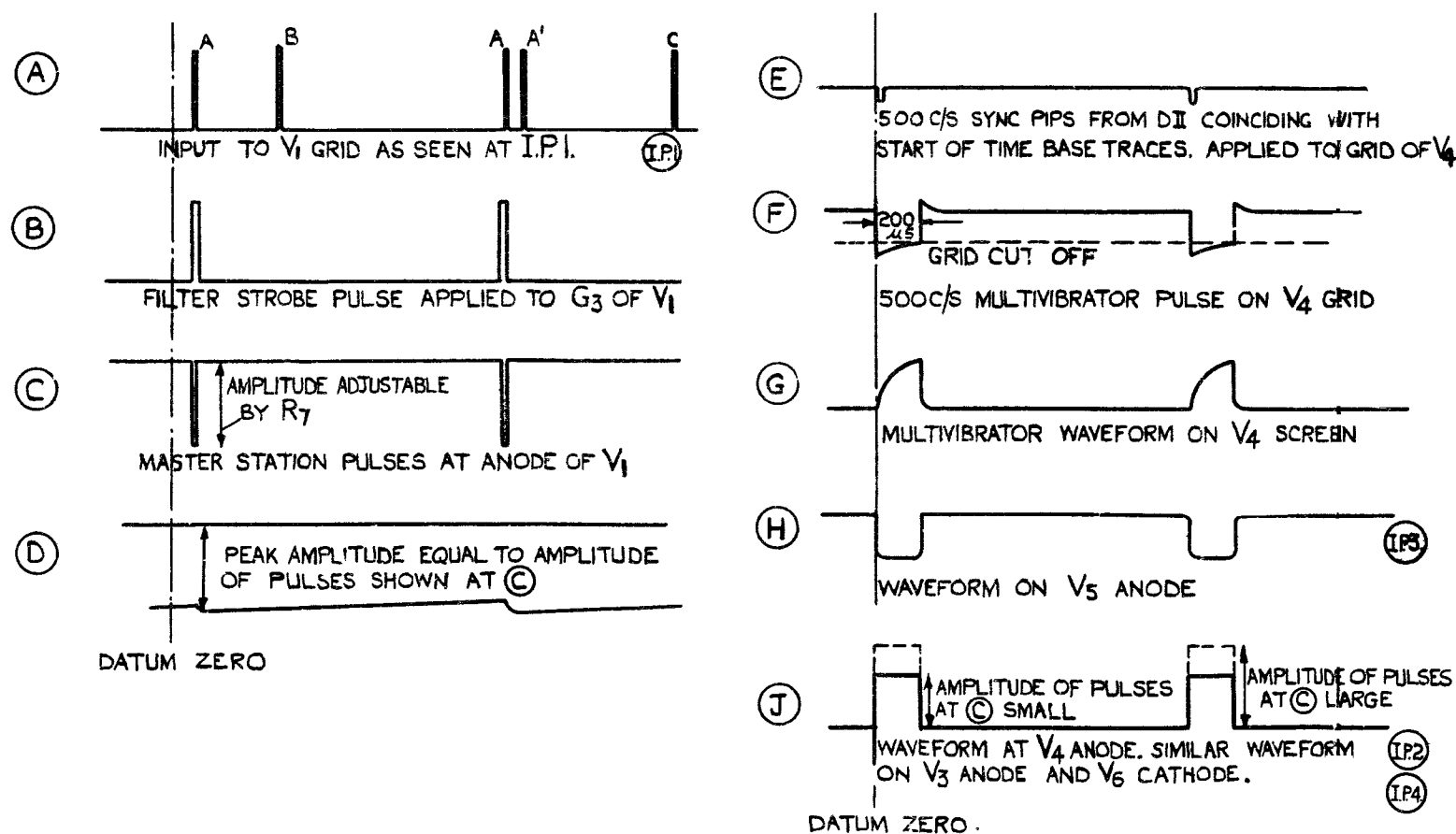


FIG. 18 A.V.C. UNIT WAVEFORMS

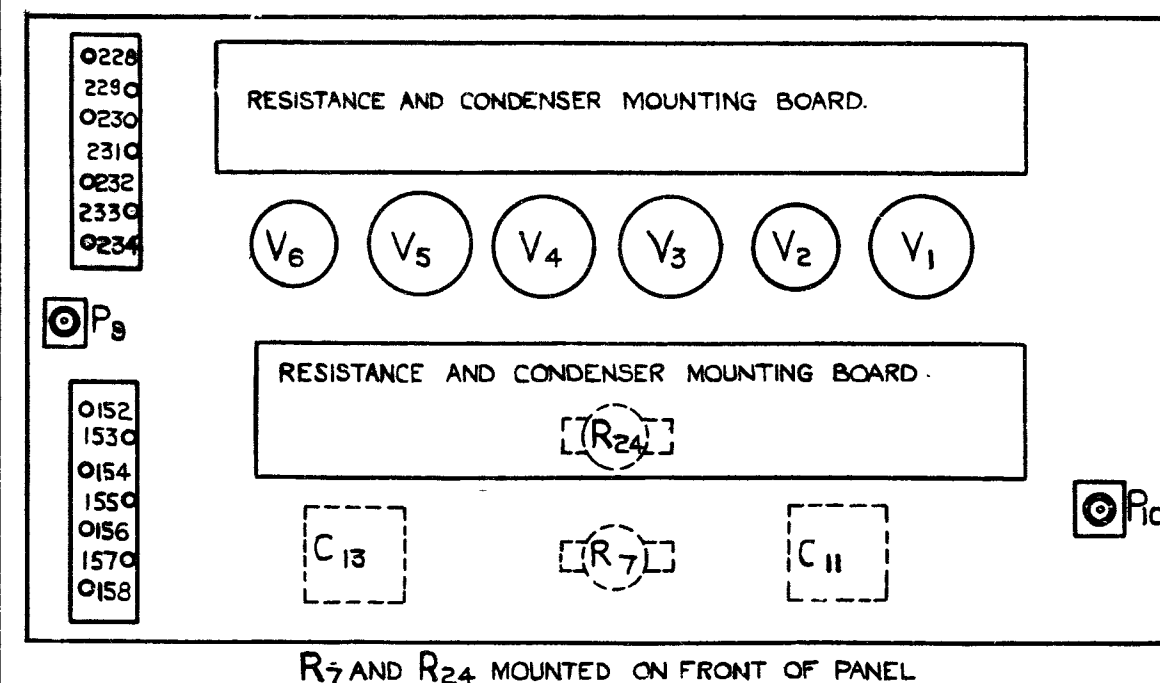


FIG. 19 A.V.C. UNIT LAYOUT

NOTE: All resistors 1/4 watt unless stated
 "cer" - ceramic disc type condensers
 resistances in ohms & capacities
 in μF unless stated.

C29 is $10\mu\text{F}$ on R.F. unit N° 26

C1 .0005

PYE PLUG
TO AERIAL

T₁

L₁

R₂
10K

C₂
.0005

R₃
10K
1W

V₁-VR 136

C₁₂
.0005

R₄
150

C₇
6 μF

C₈
.0005

C₉
.0005

C₁₀
.0005

C₁₁
.0005

C₄
15 μF

R₅
47K

C₅
75 μF

L₂

C₁₃
.0001

C₁₄
.0005

R₇
100K

R₁₄
10K
1/10 W

C₁₅
.0005

C₂₃
.0005

C₁₇
15 μF

C₁₈
2 μF
CER.

R₈
1K

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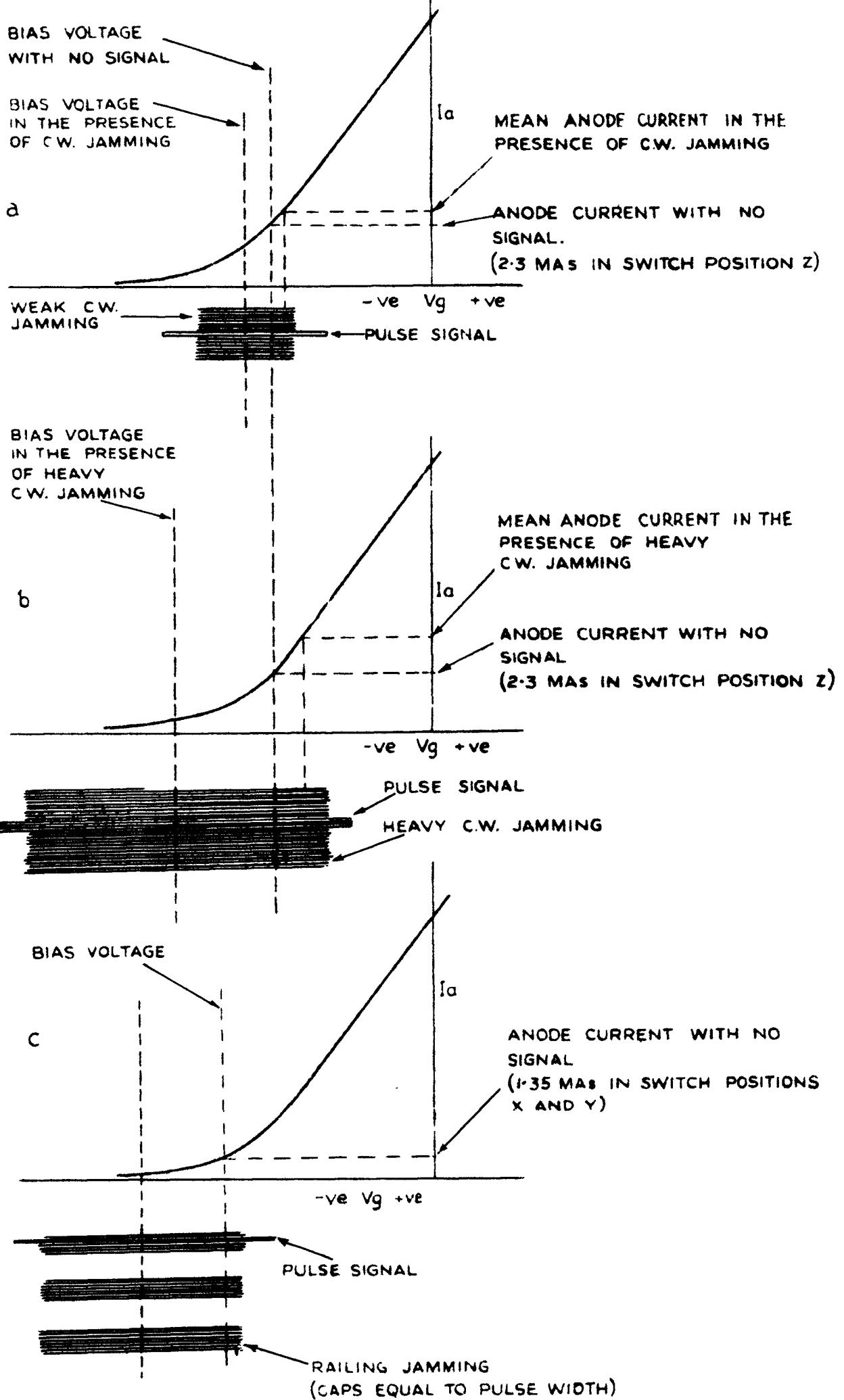
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OPERATION OF BACK BIAS I.F. STAGES

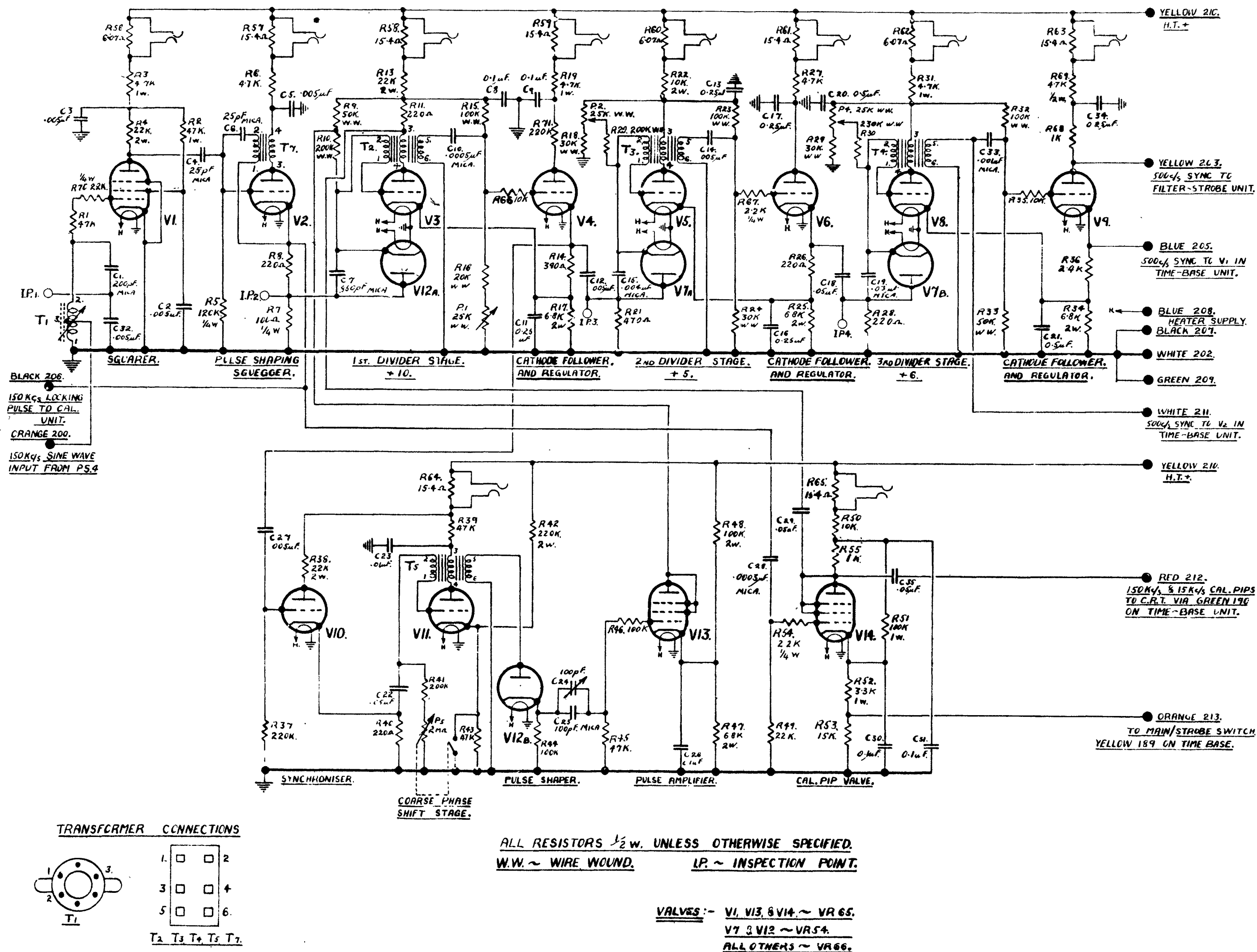
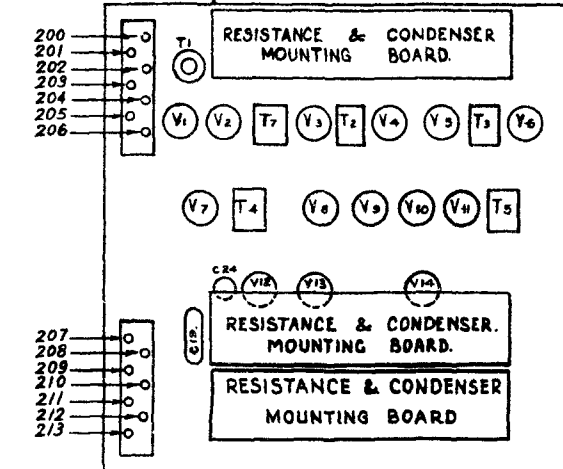
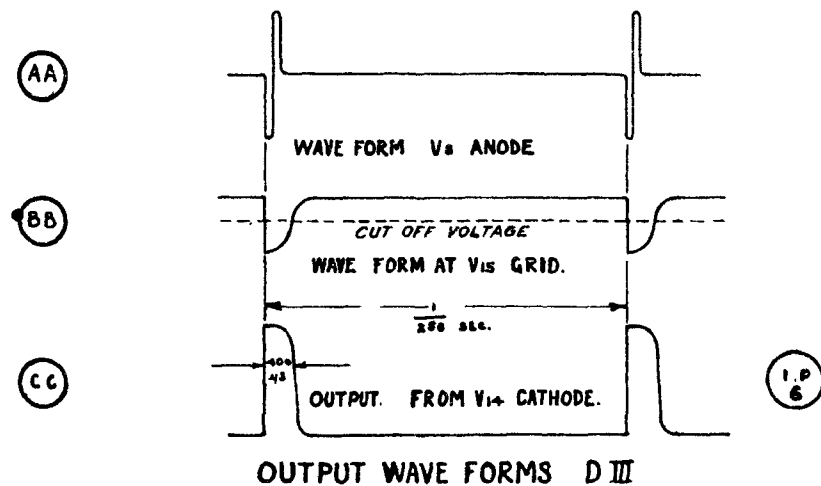
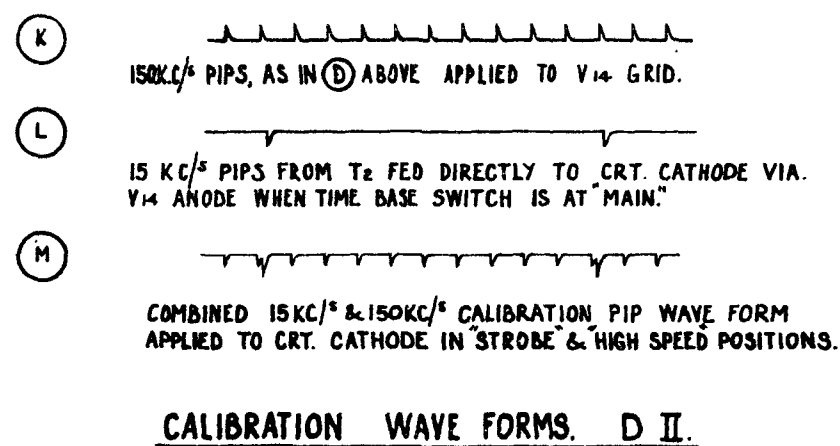
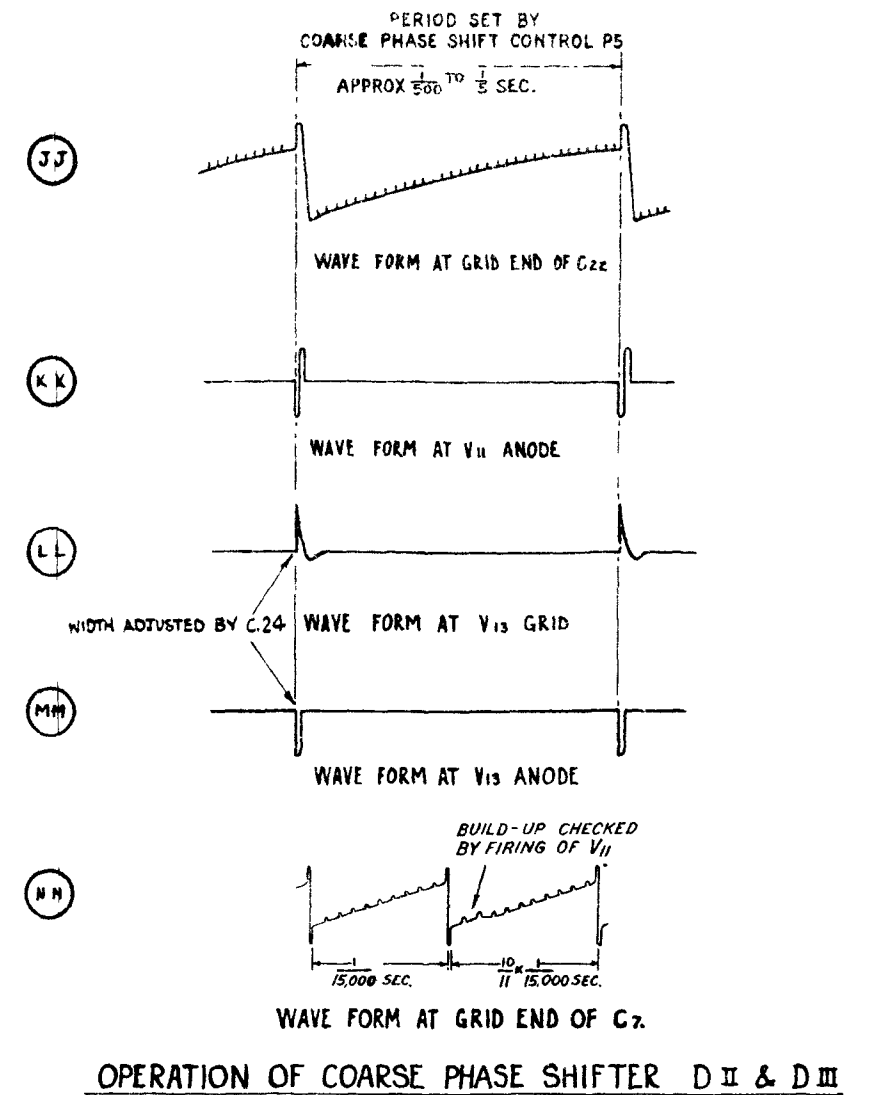
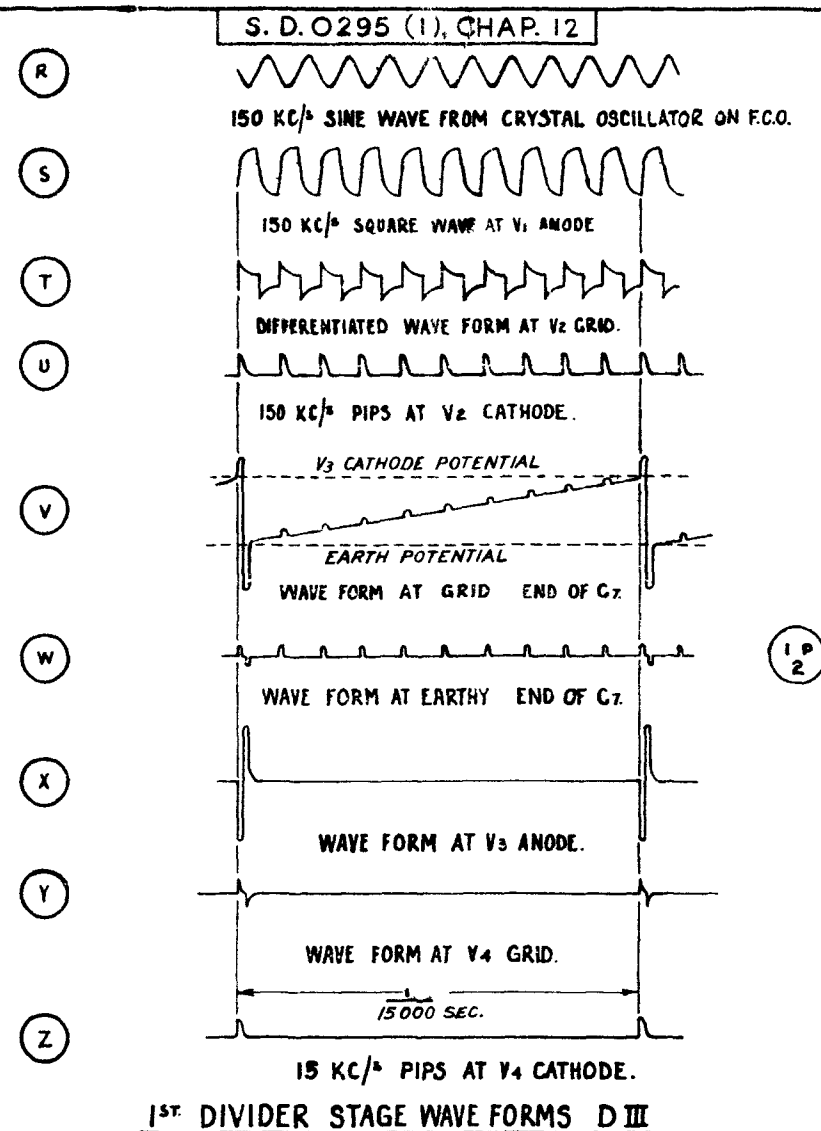
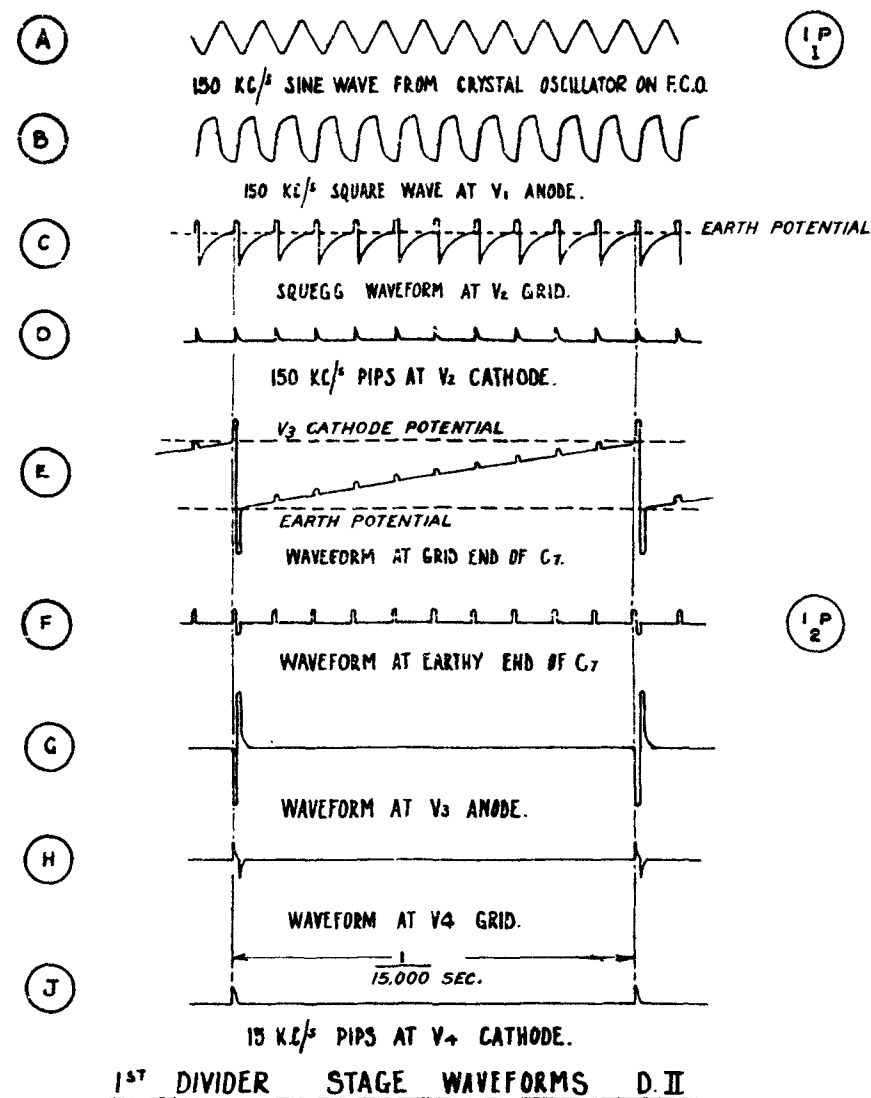


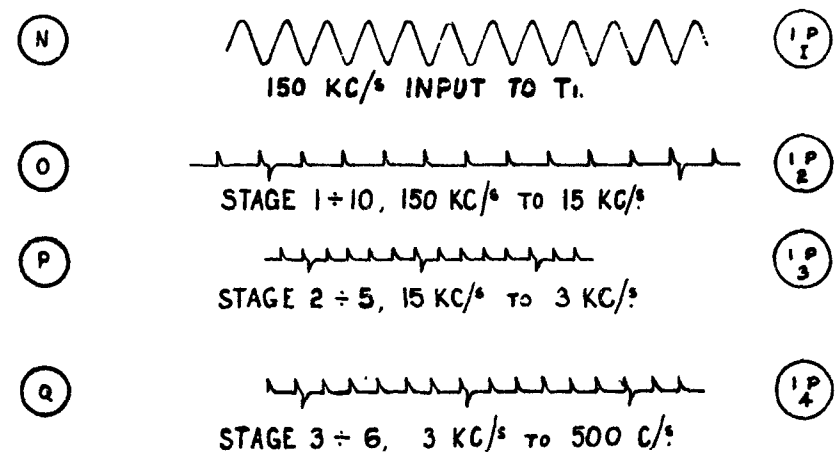
FIG.23

DIVIDER II CIRCUIT

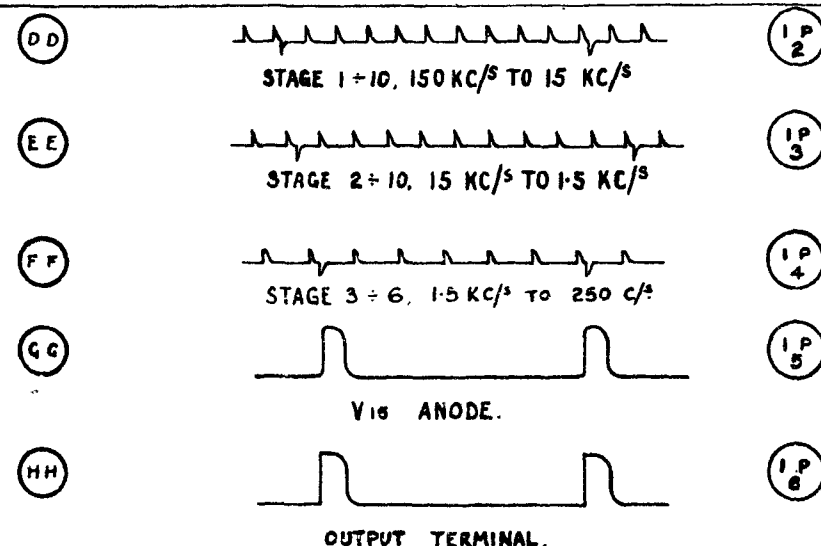
FIG.23



DIVIDER II CHASSIS (REAR VIEW)

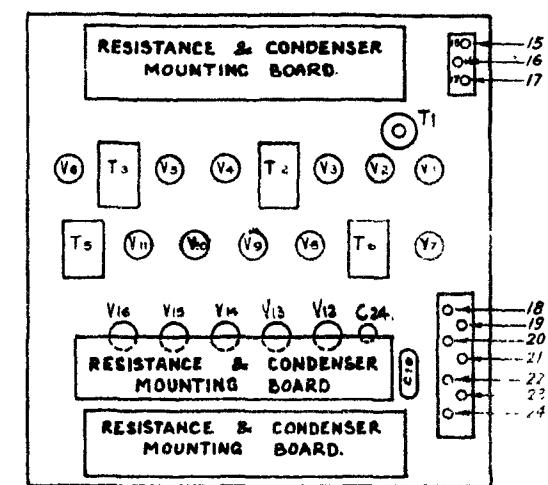


D II INSPECTION POINTS WAVE FORMS.



D III INSPECTION POINTS WAVE FORMS

DIVIDER WAVEFORMS



DIVIDER III CHASSIS (REAR VIEW)

FIG.24

FIG.24

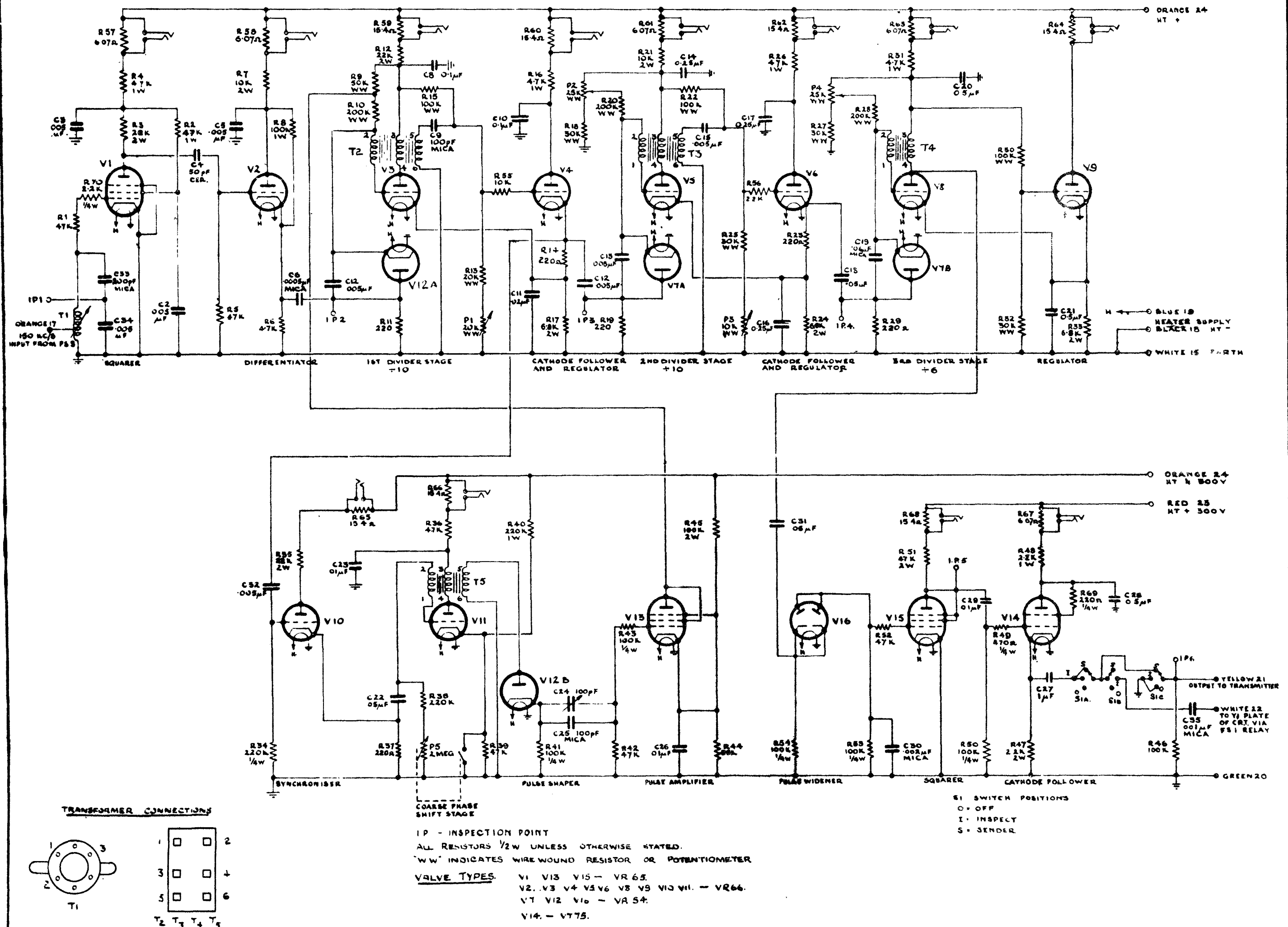


FIG.25

FIG.25

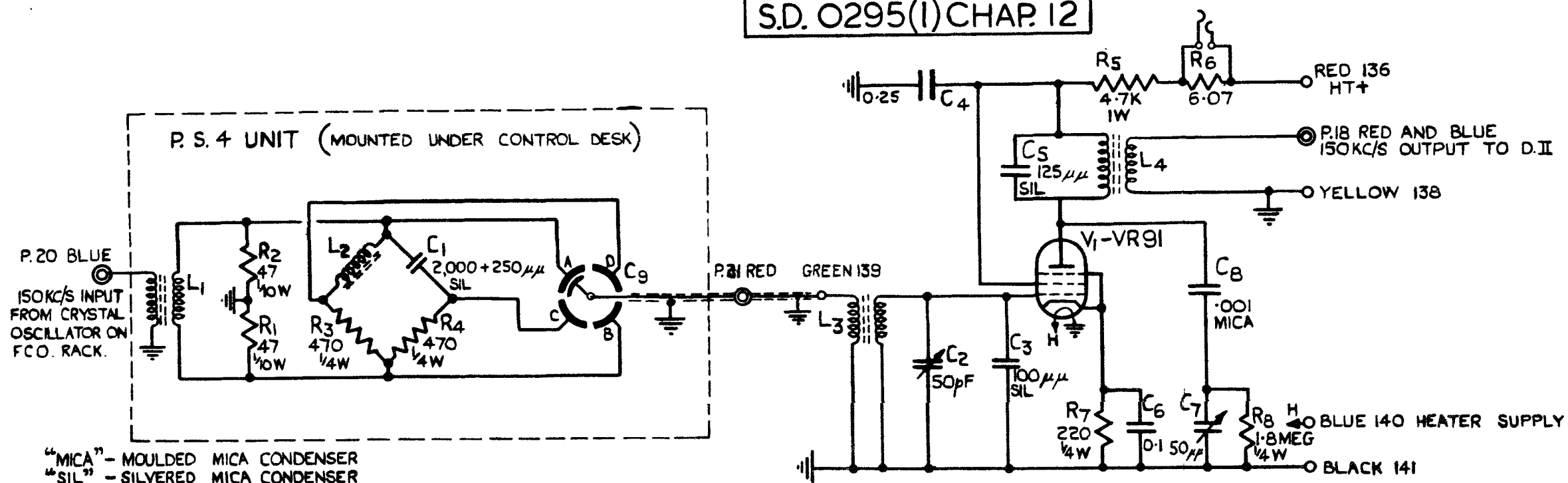


FIG. 26 PHASE SHIFTER 4—CIRCUIT

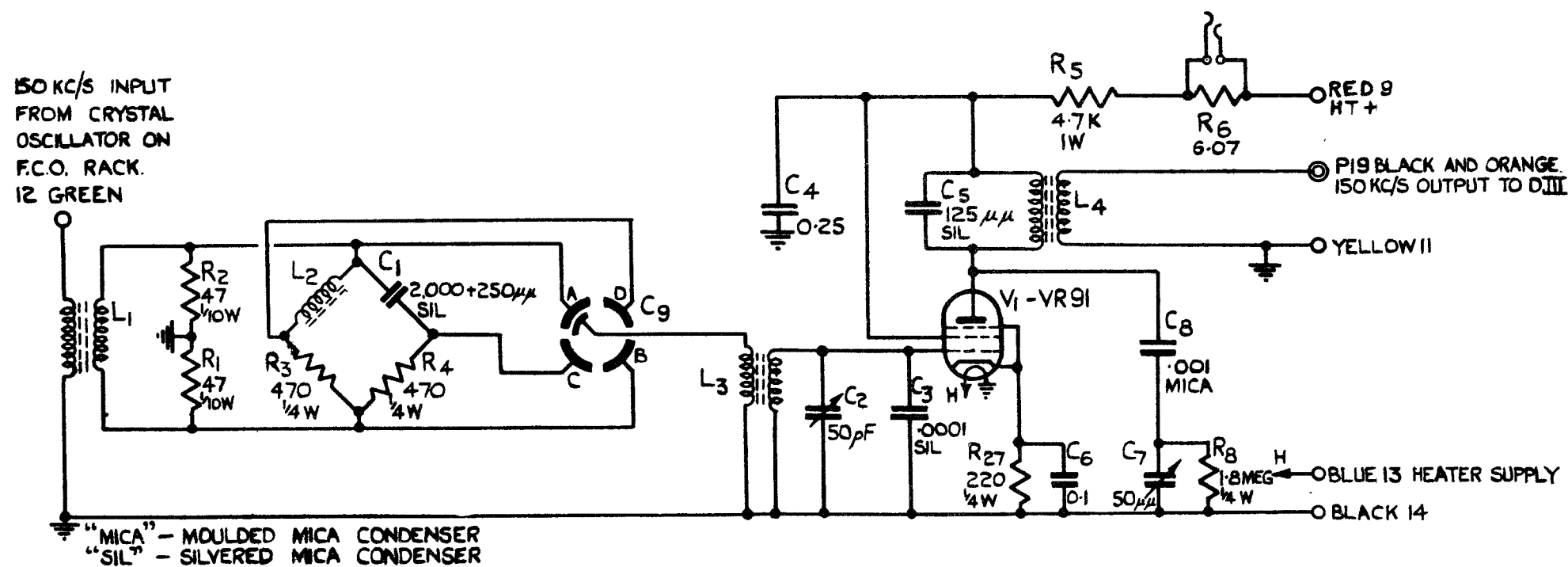


FIG. 27 PHASE SHIFTER 3 — CIRCUIT

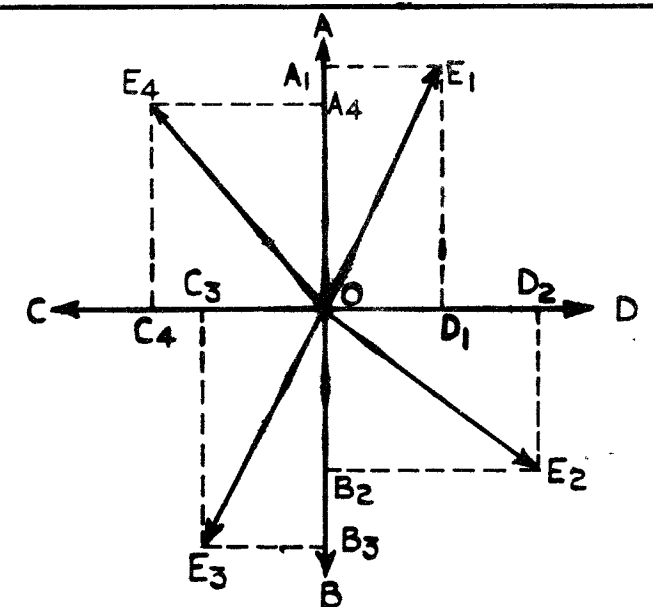


FIG. 28 PHASE SHIFTERS
— VECTOR DIAGRAM

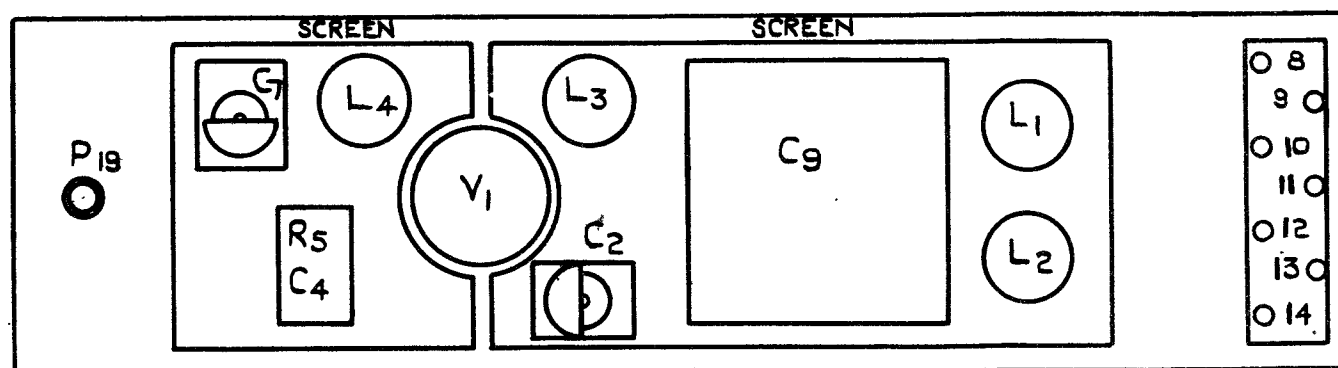


FIG. 29 PHASE SHIFTER 3 — LAYOUT

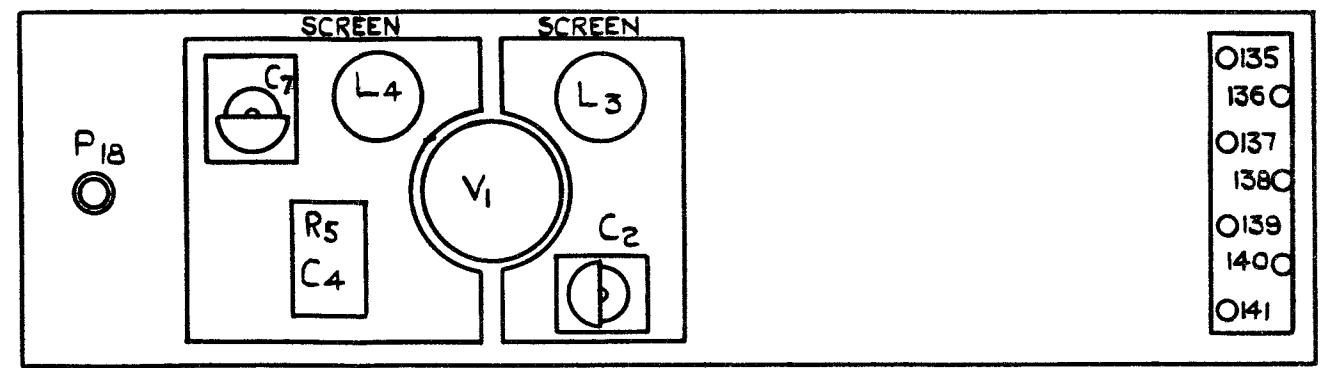
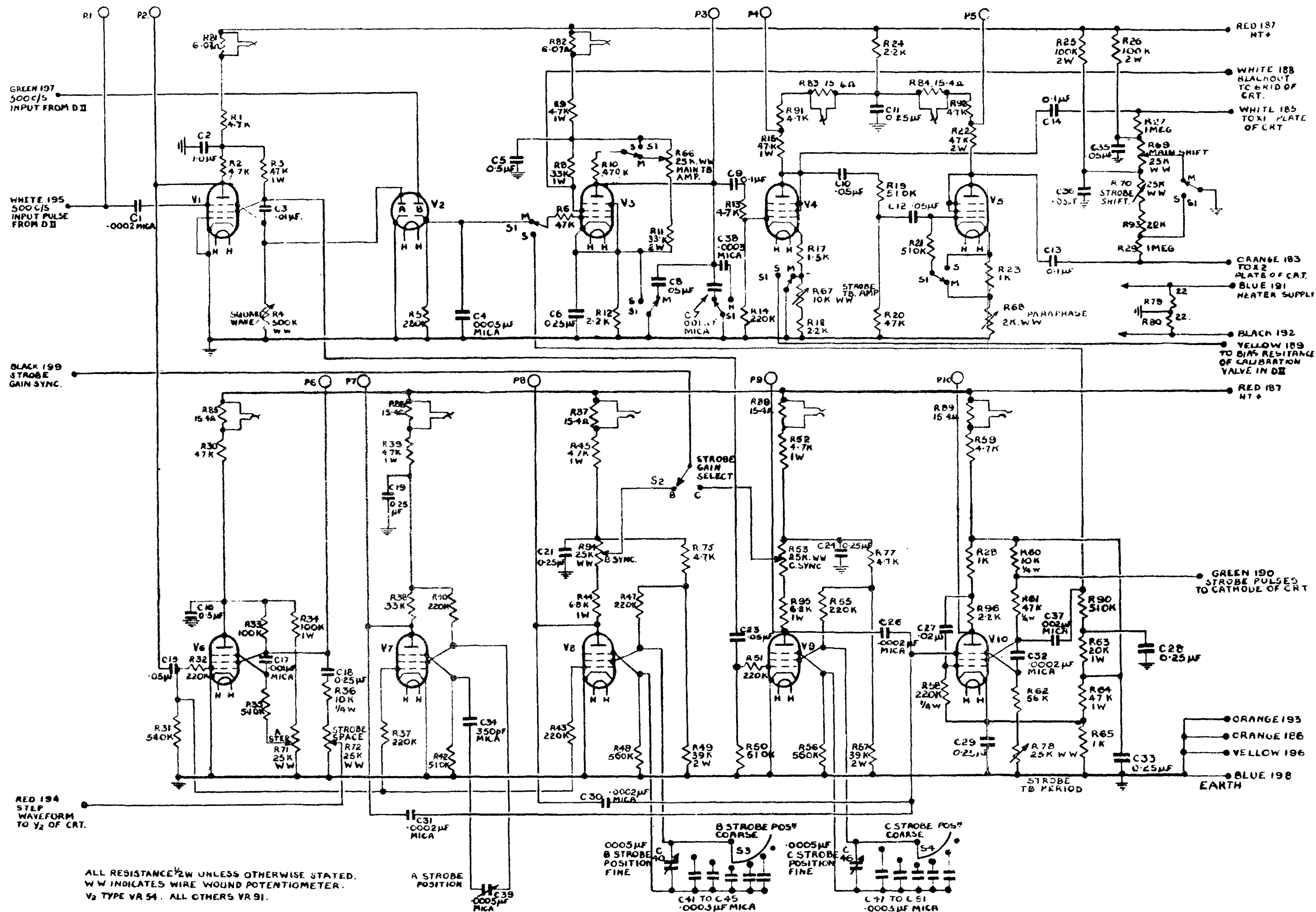


FIG. 30 PHASE SHIFTER 4—LAYOUT



TIME BASE UNIT CIRCUIT

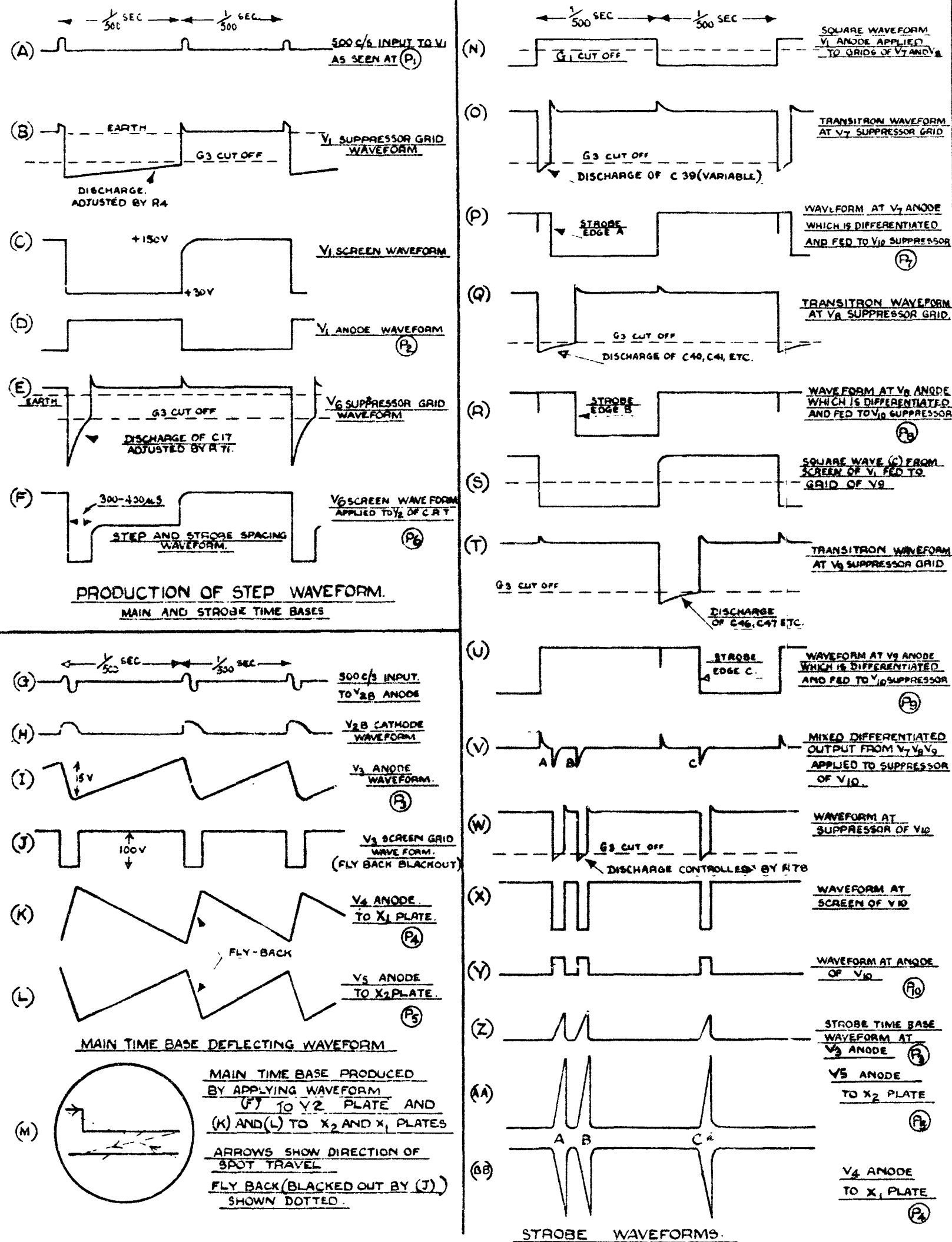
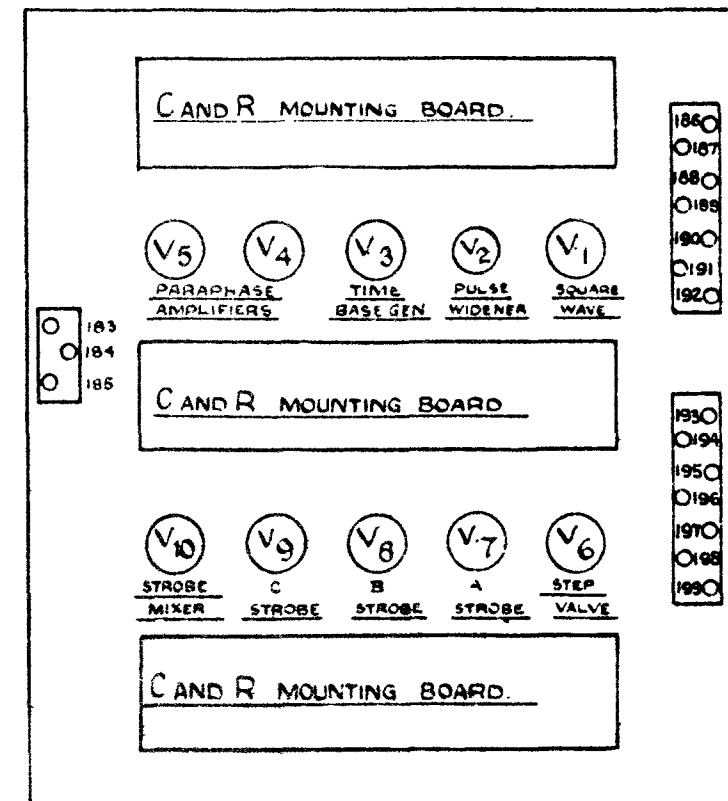


FIG.32

TIME BASE WAVEFORMS AND CHASSIS LAYOUT



TIME - BASE WAVEFORMS

(A) TO (F) AND (N) TO (Y) INCLUSIVE ARE THE SAME IN MAIN AND STROBE POSITIONS.

(G) TO (L) OCCUR ONLY IN MAIN POSITION.

(Z) TO (BB) OCCUR ONLY IN STROBE POSITION.

HIGH SPEED STROBE WAVEFORMS ARE SIMILAR TO (Z) (AA) AND (AB) EXCEPT THAT THE DURATION OF THE PULSES IS SHORTER AND HENCE THE SLOPE OF THE PULSE FRONTS IS STEEPER

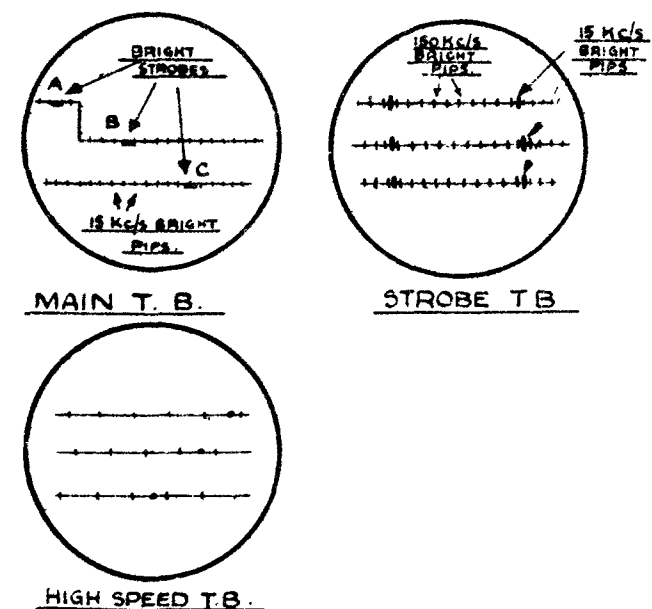


FIG.32

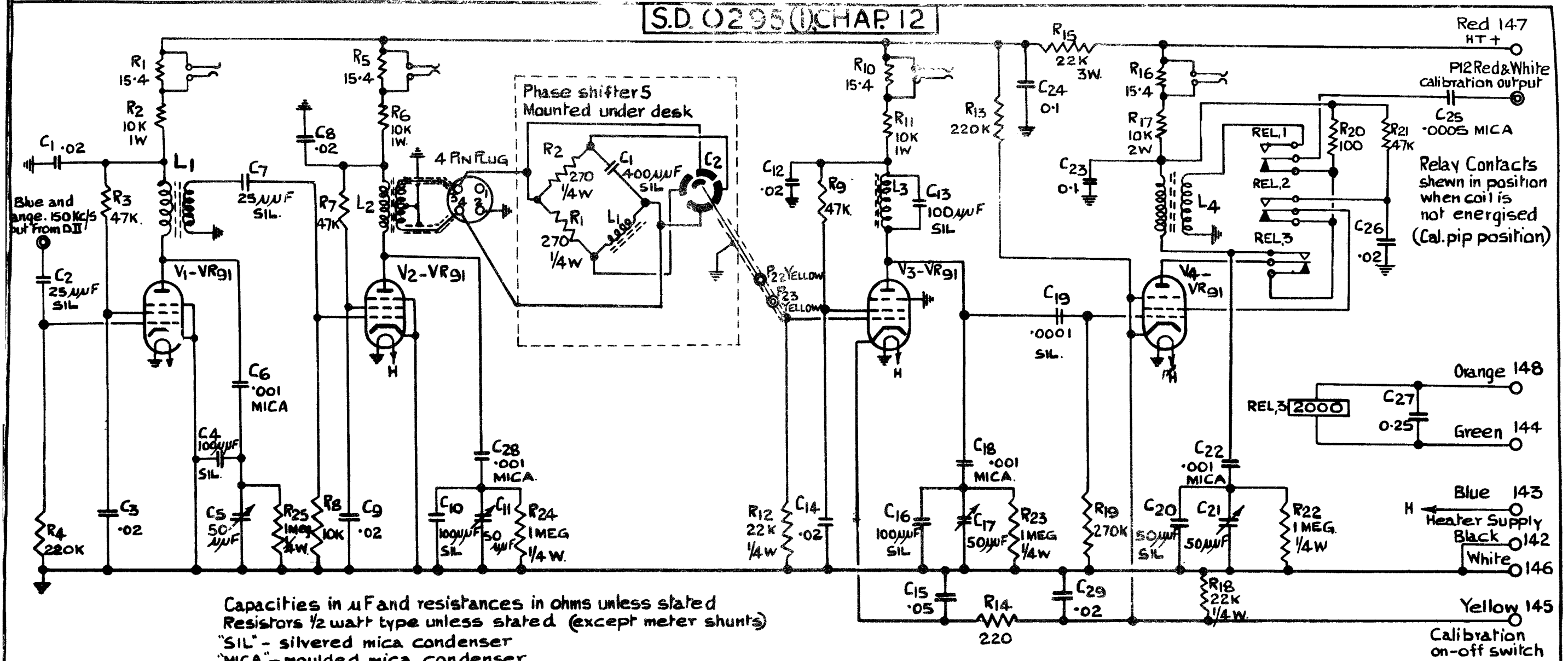
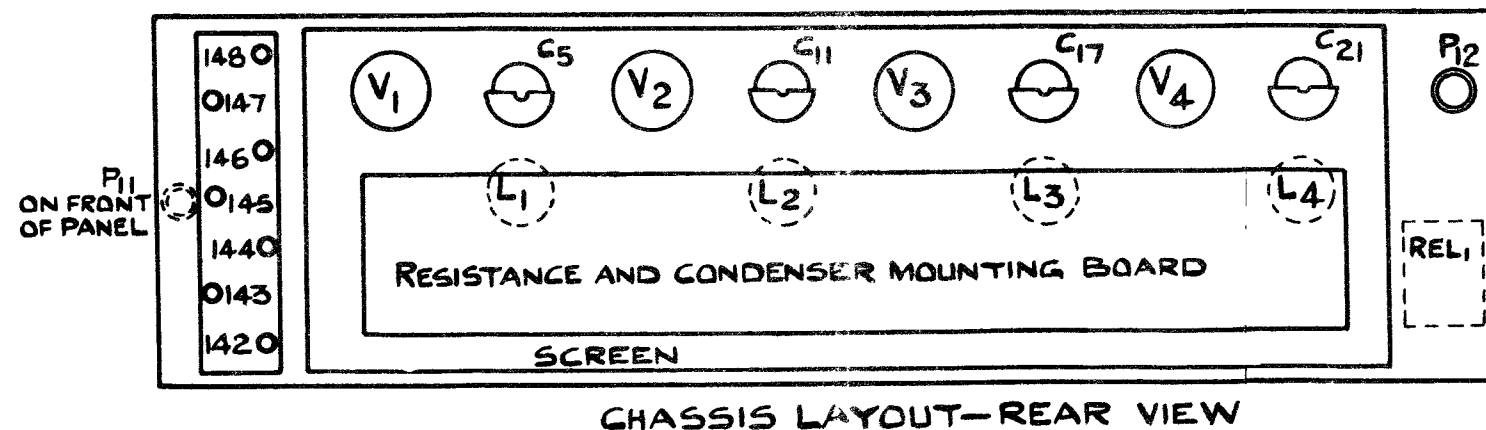
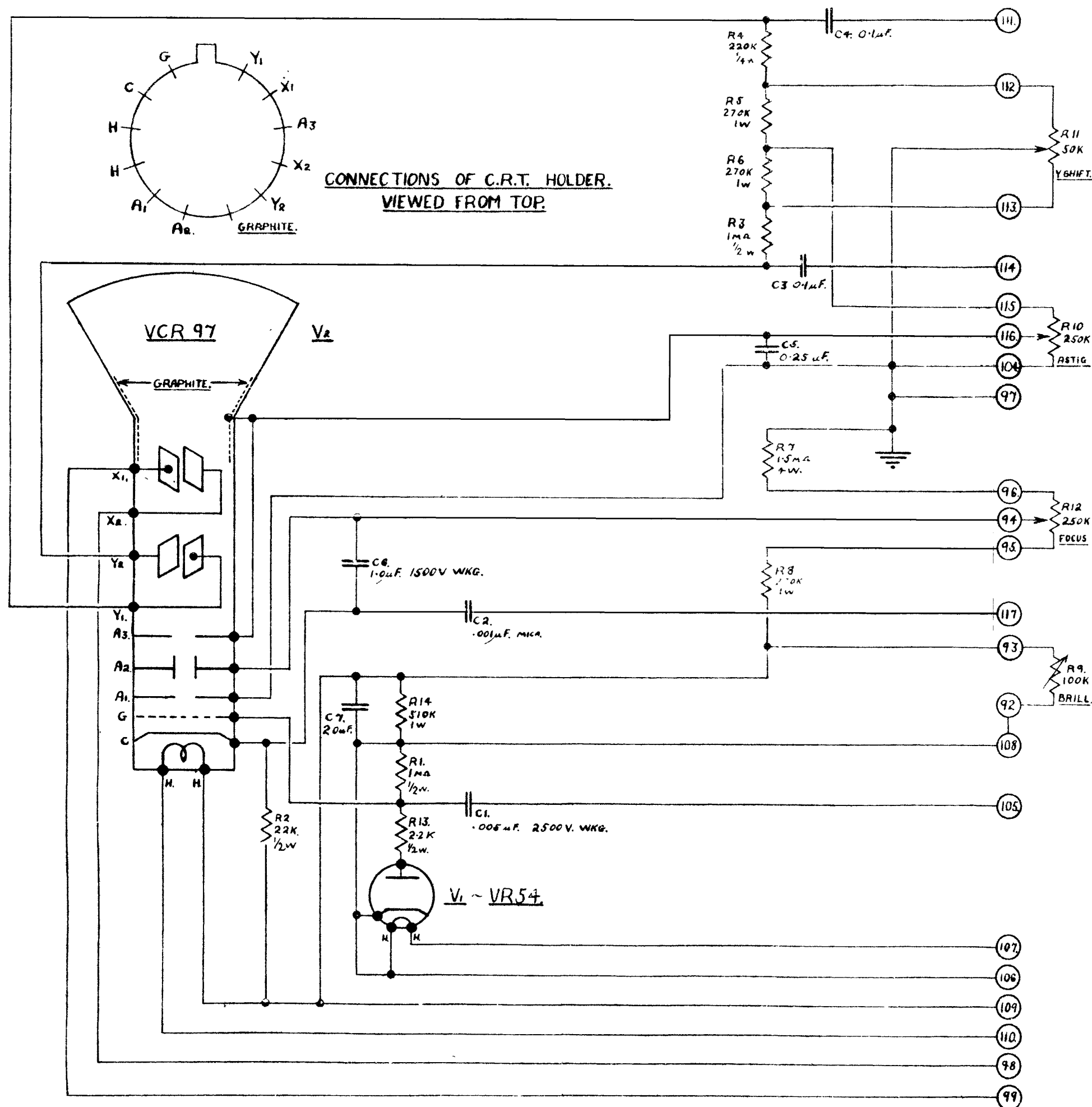


FIG.33 1.5 Mc/s CALIBRATION UNIT-CIRCUIT

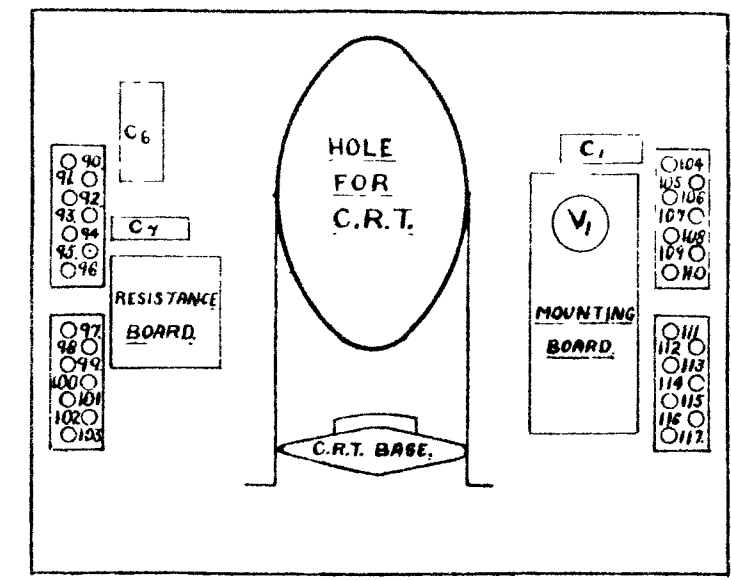


P23 AND 4 PIN W PLUG, ARE MOUNTED ON FRONT PANEL

FIG.34 1.5 Mc/s CALIBRATION UNIT-LAYOUT



CONNECTIONS OF C.R.T. HOLDER.
VIEWED FROM TOP.



CHASSIS LAYOUT - REAR VIEW.

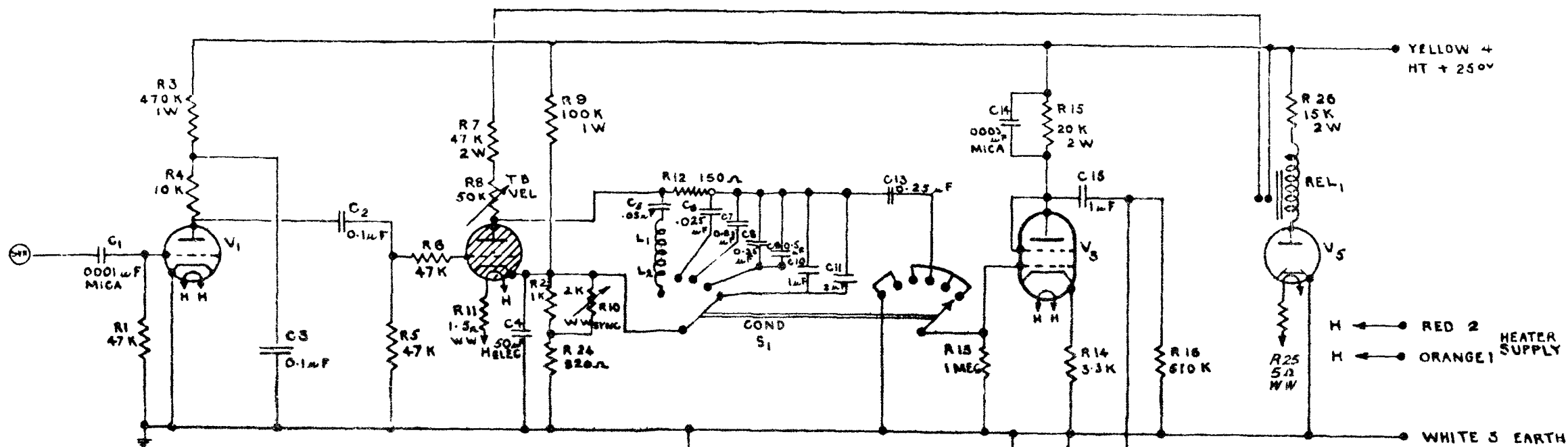
- (111) ~ BLACK. PULSES FROM RECEIVER UNIT OR F.6.1.
- (112) ~ BLUE
- (113) ~ GREEN.
- (114) ~ YELLOW. STEP WAVEFORM & 15 m/c CAL WAVE
- (115) ~ WHITE. H.T. + V_e 300V FROM PP3.
- (116) ~ RED.
- (104) ~ BLACK.
- (97) ~ BLACK.
- (95) ~ ORANGE.
- (94) ~ WHITE.
- (95) ~ RED.
- (117) ~ ORANGE CAL. PIPS & STROBE BRIGHTENING
- (93) ~ YELLOW
- (92) ~ GREEN
- (108) ~ WHITE. - 2000V. E.H.T.
- (105) ~ BLUE BLACKOUT. FROM TIME BASE UNIT.
- (107) ~ YELLOW } HEATER SUPPLY.
- (106) ~ GREEN. }
- (109) ~ RED. } TUBE HEATER SUPPLY.
- (110) ~ ORANGE }
- (98) ~ BLUE }
- (99) ~ GREEN. } T.B. WAVEFORM.

R9
R10
R11
R12 } MOUNTED ON BRIGHTNESS & FOCUS PANEL

FIG.35

C. R. T. UNIT CIRCUIT

FIG.35



RESISTORS 1/2 W UNLESS OTHERWISE STATED.

VALVE TYPES.

V₁ - H 68 or VT 78

V₂ - T41 OR VGT 121

VJ - KT 68 OR 6V66

V4-VCR 138

VJ - D42

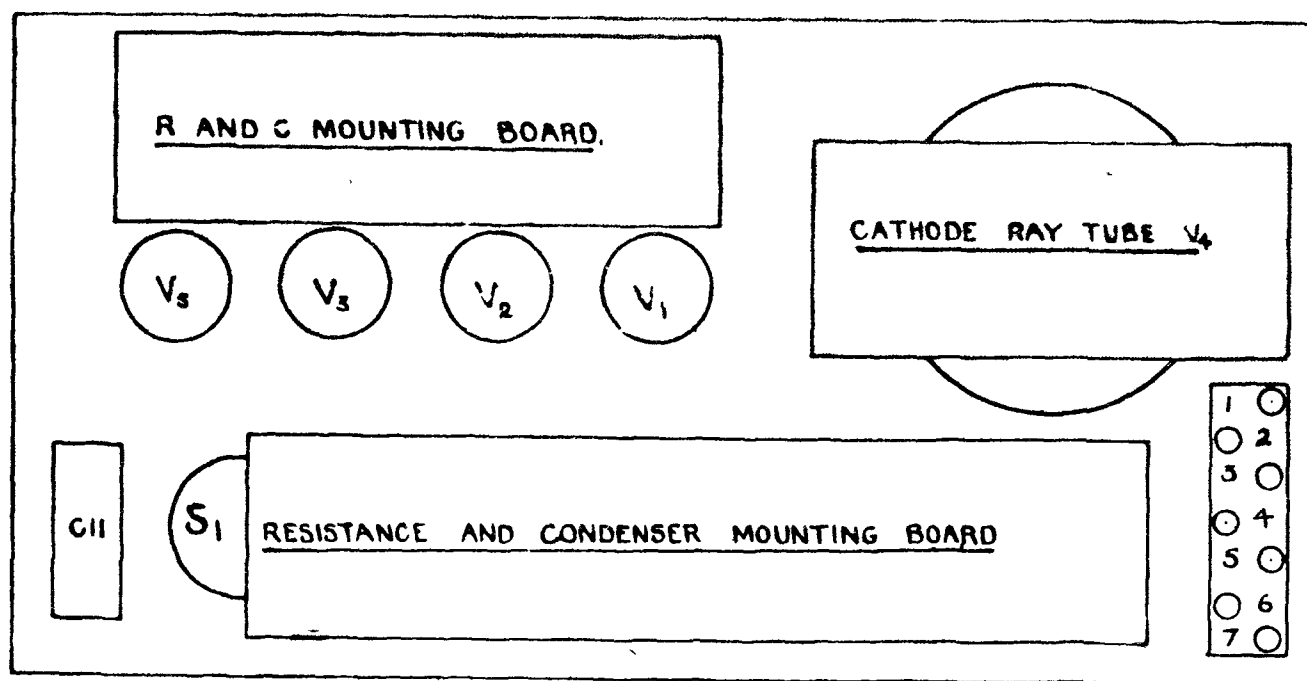
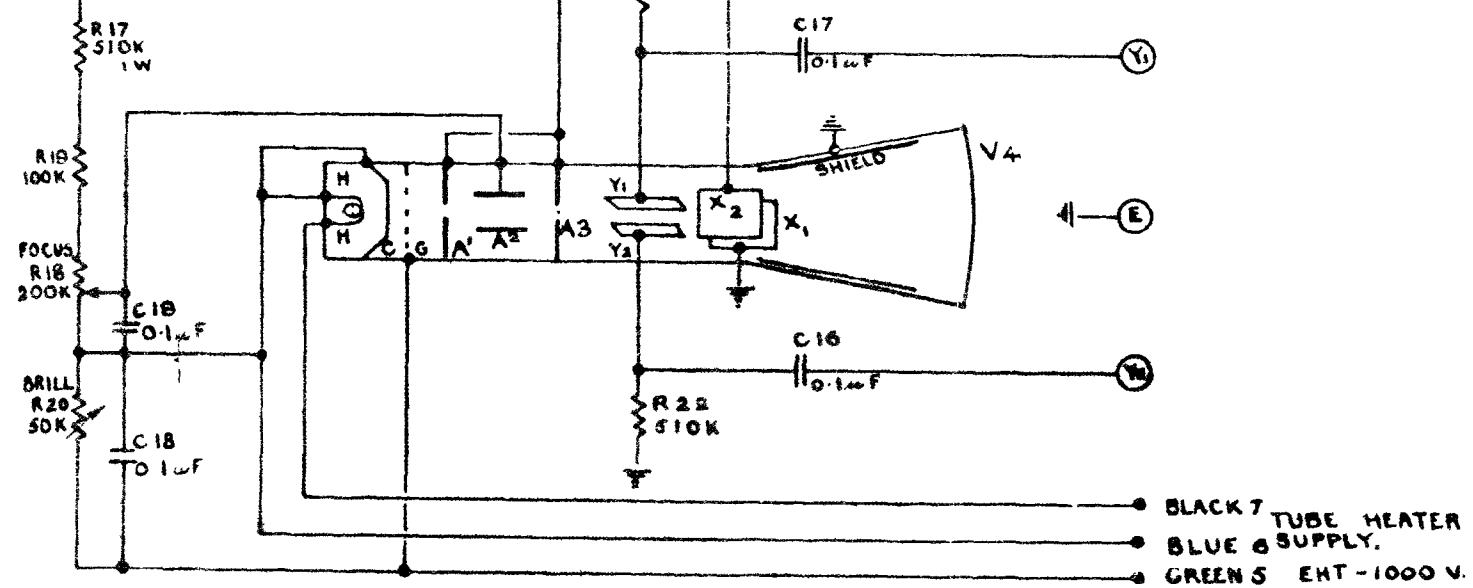
COILS L₁ L₂ ARE DEFLECTOR COILS
MOUNTED ON NECK OF CRT

(S_{10}) (Y_1) (Y_2) (E) ARE INSULATED

TERMINALS MOUNTED ON FRONT PANEL

WW - WIRE WOUND RESISTANCE.

ELEC- ELECTROLYTIC CONDENSER



R8 R10 R18 R20 ARE MOUNTED INSIDE FRONT PANEL.
CHASSIS LAYOUT REAR VIEW.

OSCILLOGRAPH UNIT CIRCUIT

FIG 37

FIG.37

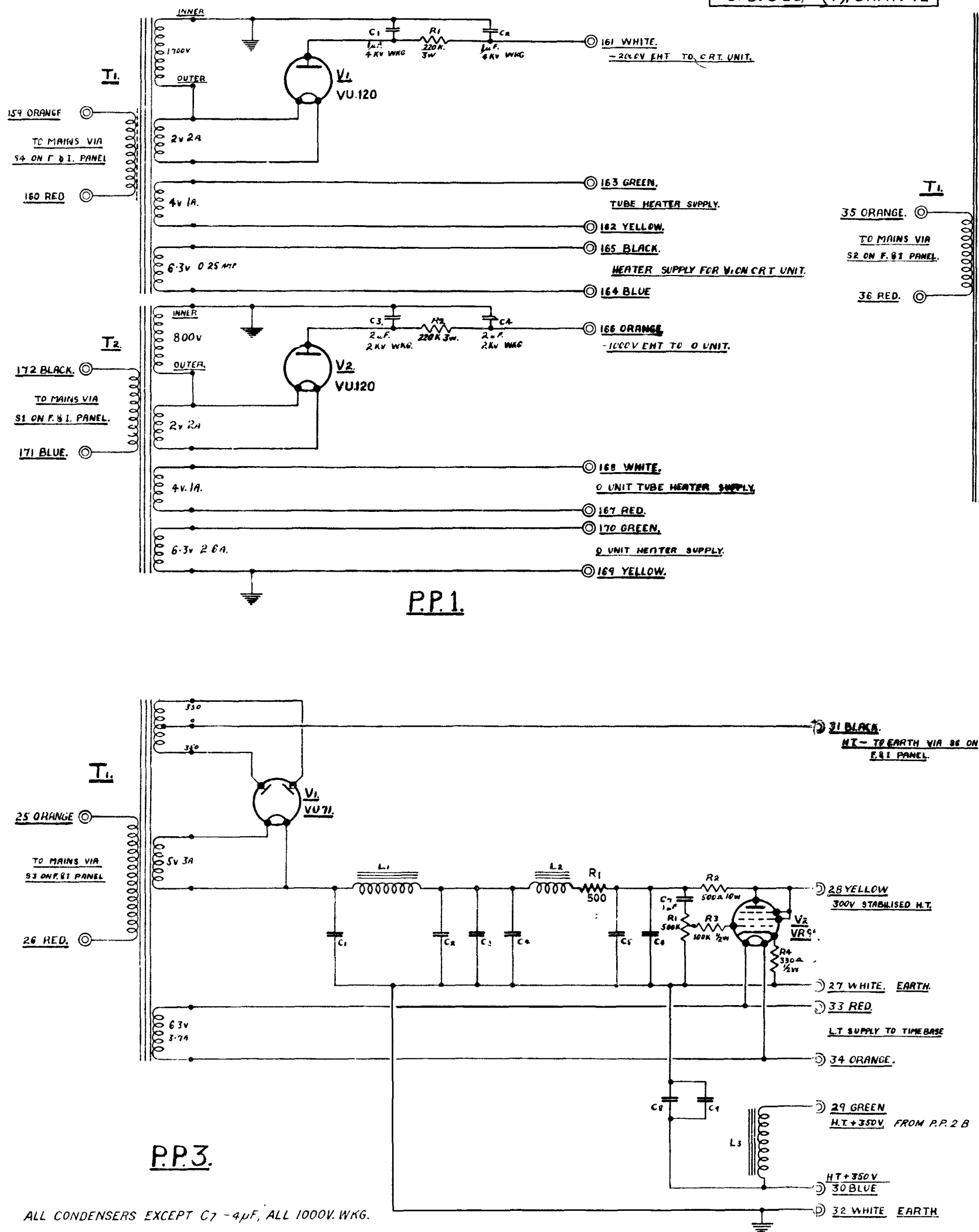


FIG. 38 POWER PACKS P.P.1, P.P.2 AND P.P.3 CIRCUITS

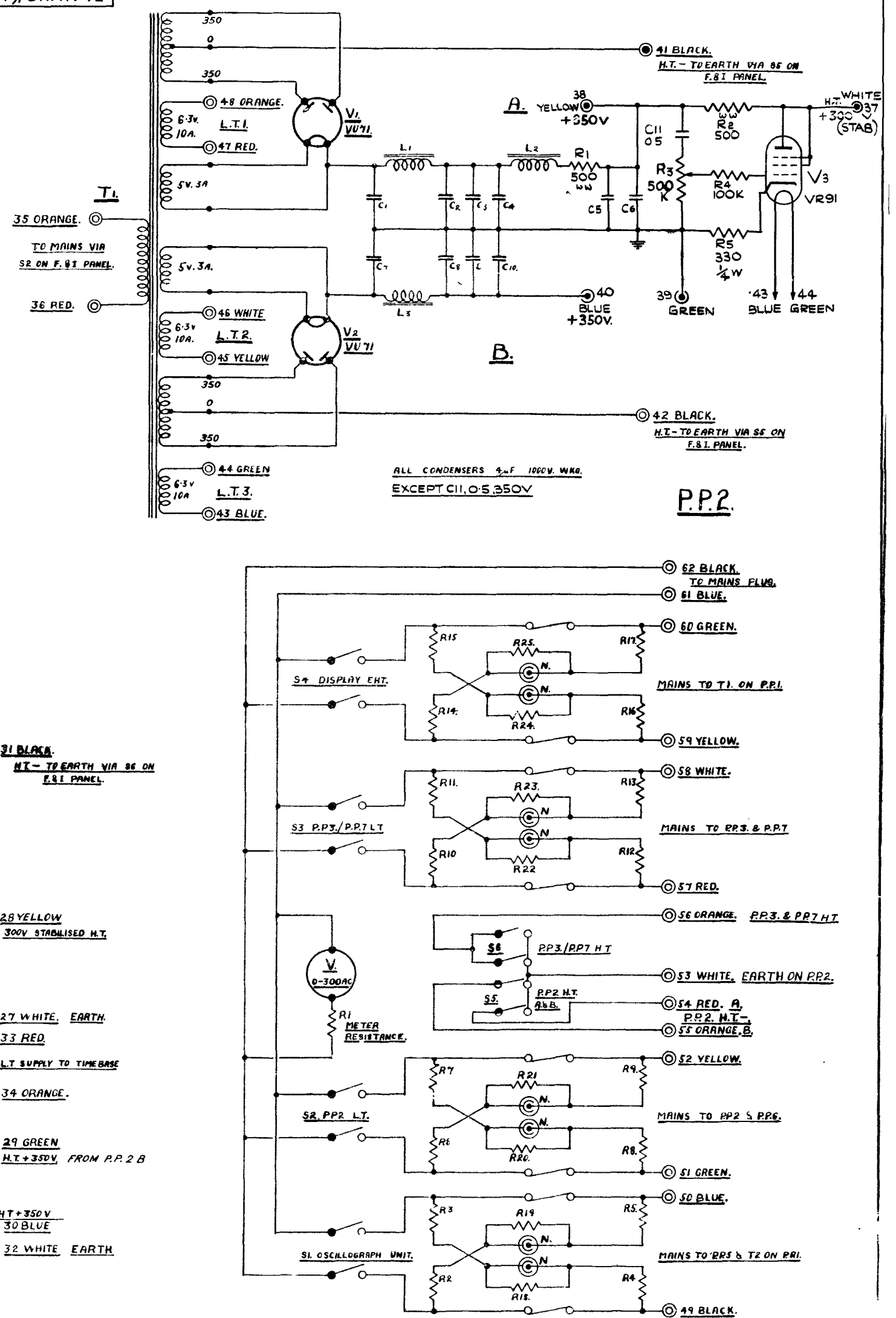
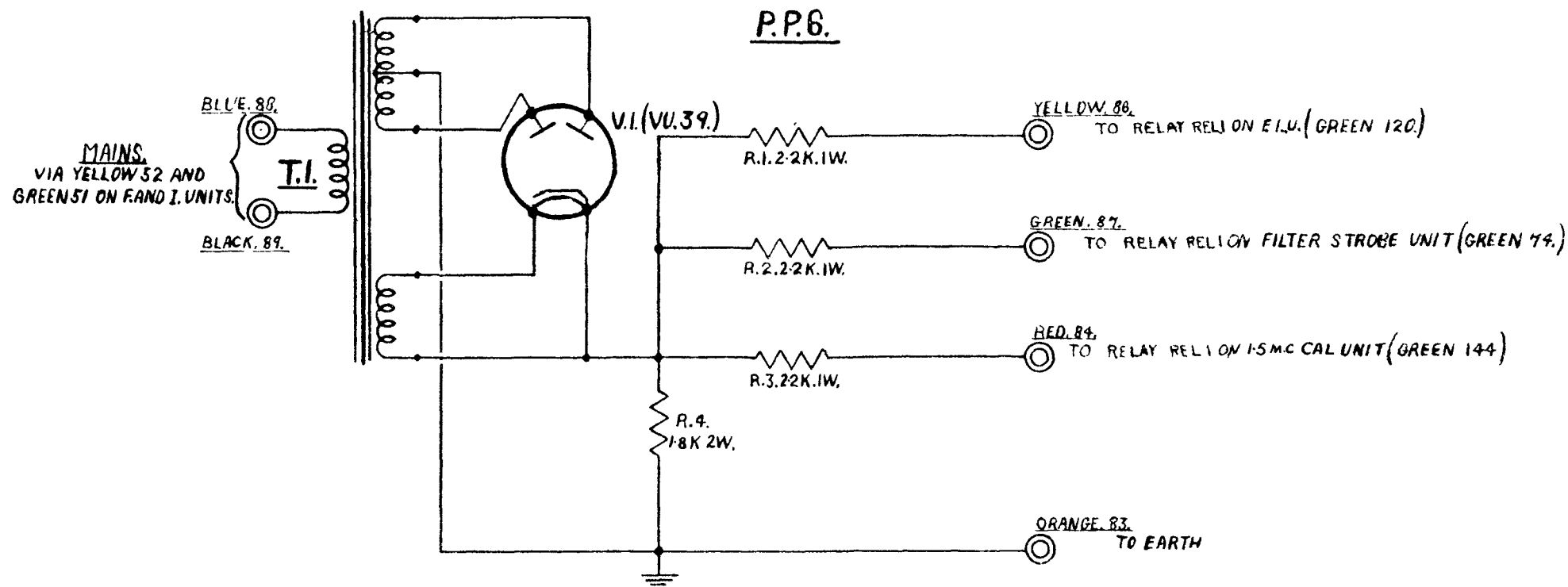
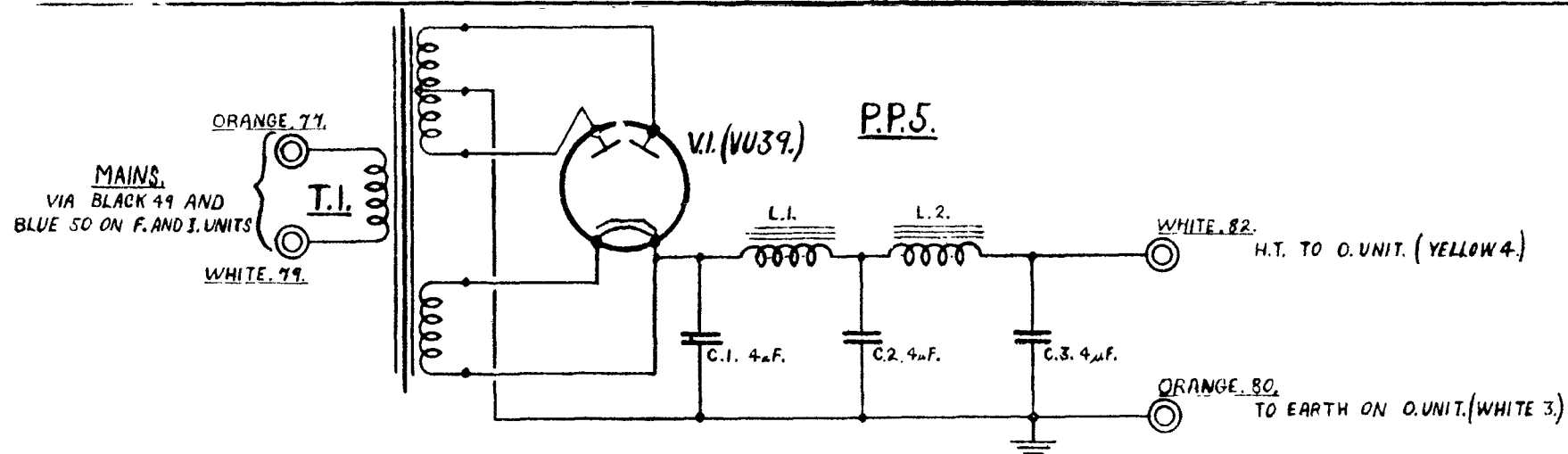


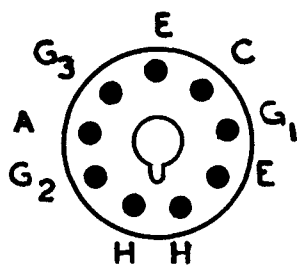
FIG. 39 - FUSE AND
INDICATOR PANEL CIRCUIT

N ~ NEON BULBS.
R2 TO R17 ~ 220K $\frac{1}{2}$ W.
R18 TO R25 ~ 1MEG $\frac{1}{2}$ W.

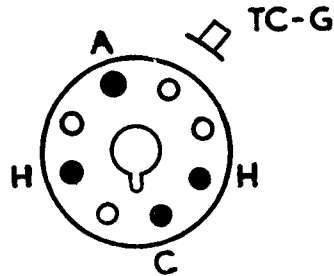
FIGS. 38-39



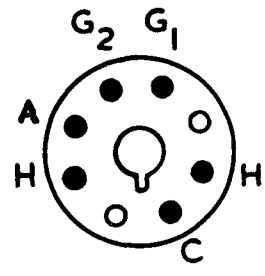
POWER PACKS P.P.5 AND P.P.6 CIRCUITS



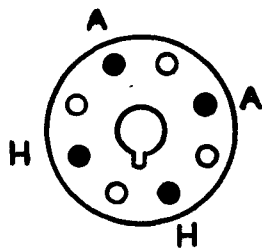
VR 91



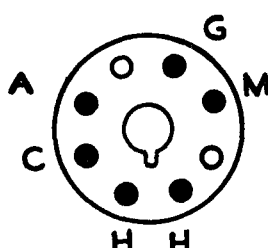
H63 VT73



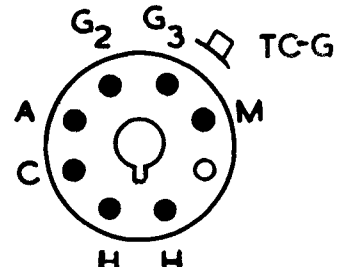
VT 75 OR
KT 63 (6V6G) OR
KT 66 (6L6G)



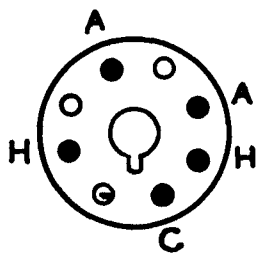
VU 71



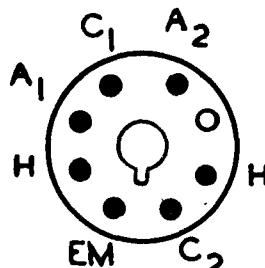
VR 66 & T41 (VGT121)



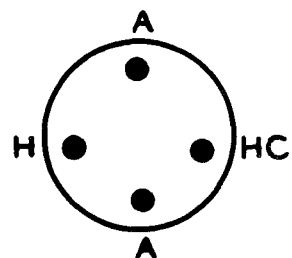
VR 65 & VR116



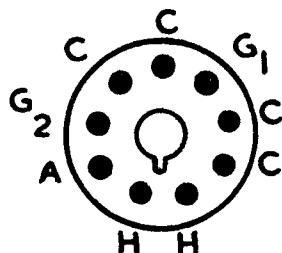
6X5 6



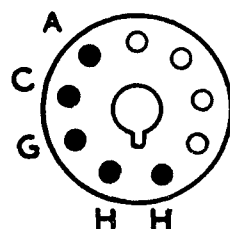
VR 54



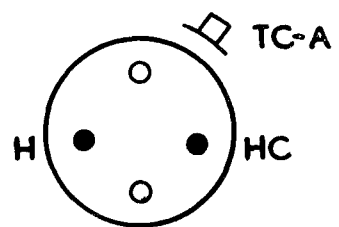
VU 39



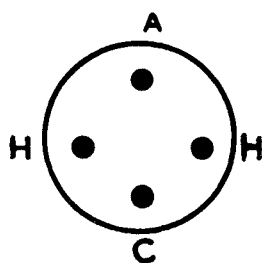
VR136 (RL7)



VR137 (RL16)



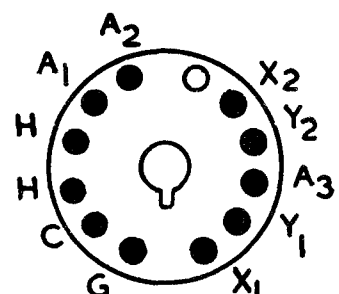
VU120



D 42 (ARD4)

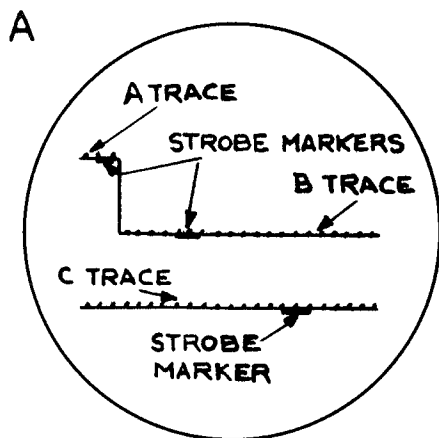


VR92

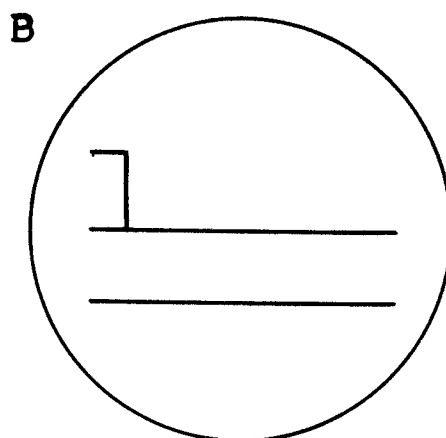


VCR 97 & VCR138

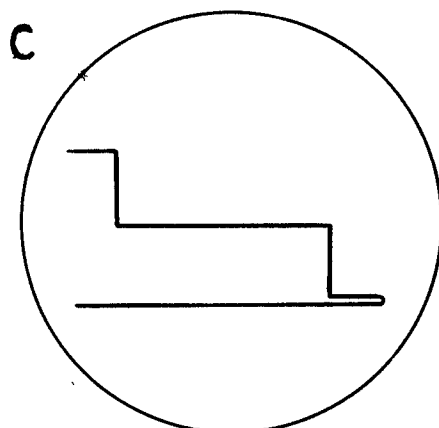
VALVE BASE CONNECTIONS



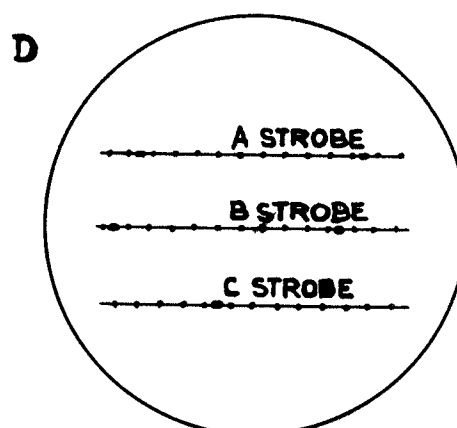
MAIN TIME BASE SHOWING 15 KC/S CAL.PIPS



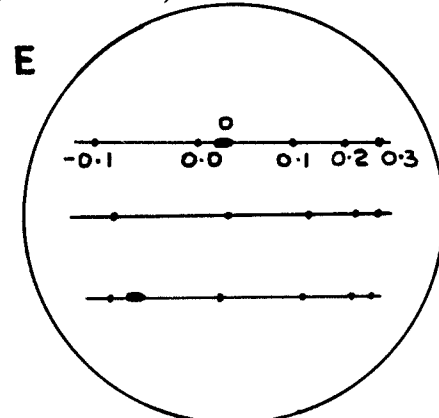
INCORRECT ADJUSTMENT OF "SQUARE WAVE" (R_4 TOO LARGE) CAL.PIPS NOT SHOWN



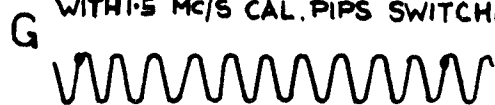
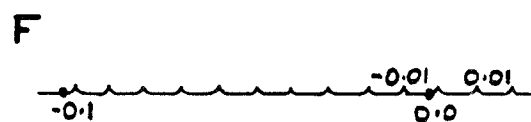
INCORRECT ADJUSTMENT OF "SQUARE WAVE" (R_4 TOO SMALL) CAL.PIPS NOT SHOWN



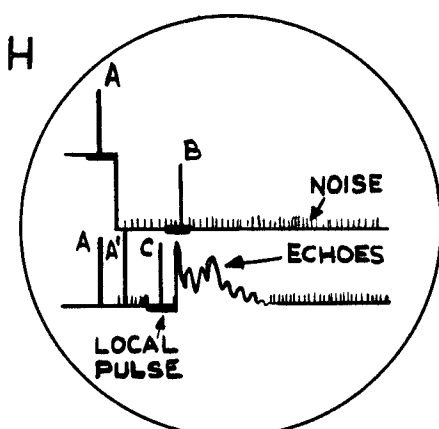
STROBE TIME BASE
SHOWING 15 KC/S AND 150 KC/S CAL.PIPS



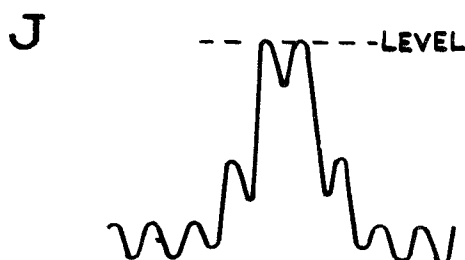
HIGH SPEED STROBE TIME BASE
NOTE NON-LINEARITY



1.5 MC/S SINE WAVE CALIBRATION WAVE



MAIN TIME BASE AS SEEN AT "C" STATION
NOTE REDUCED GAIN ON STEP (DUE TO A.V.C)
AND ON C STROBE DUE TO STROBE GAIN CONTROL



METHOD OF BALANCING 1.5 MC/S
CALIBRATION WAVE ON PEAK OF
"TRIANGULAR" PULSE.

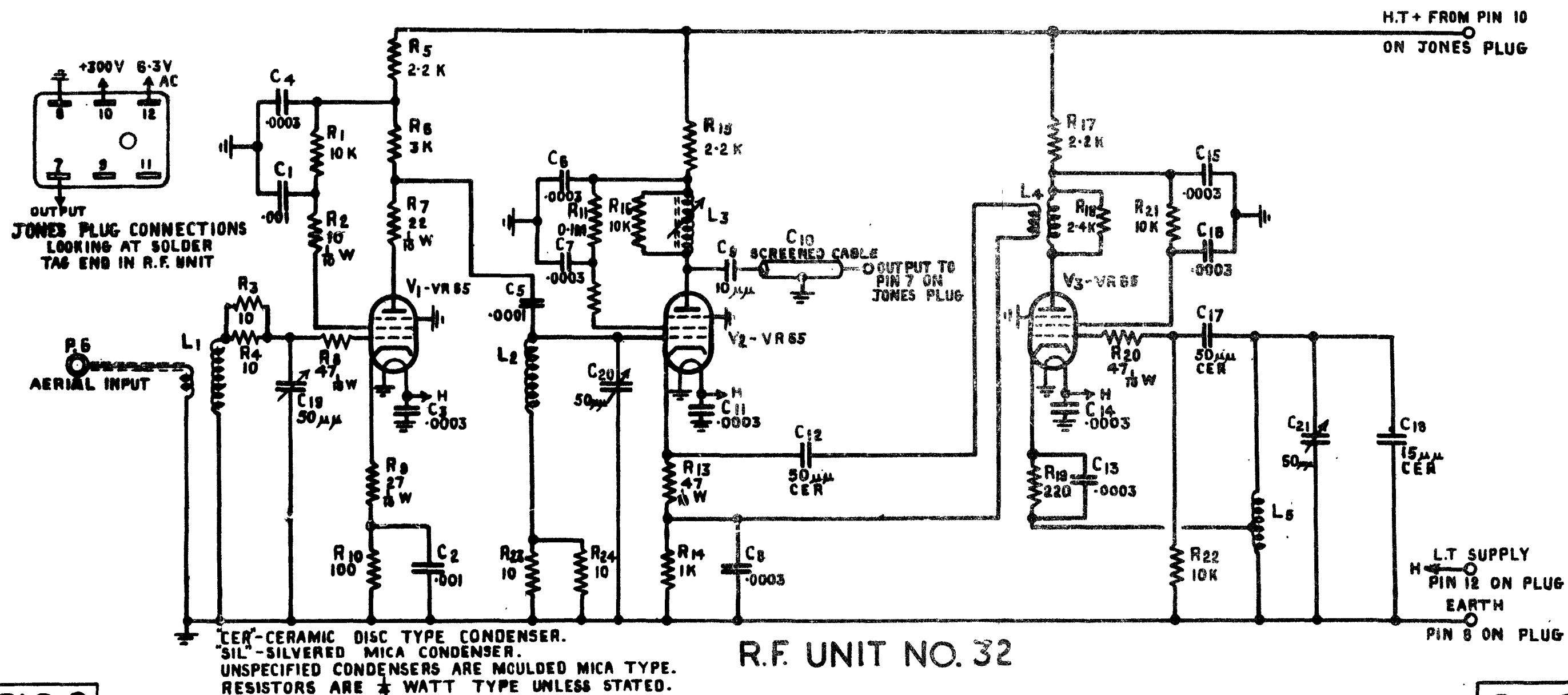
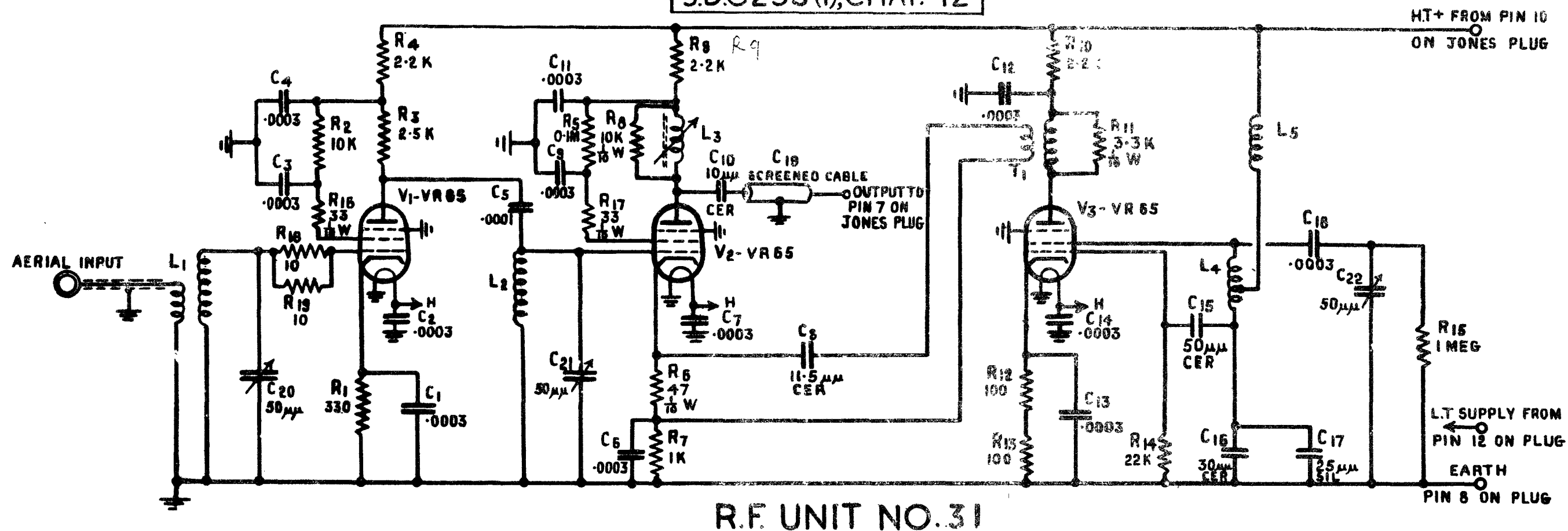


FIG. 6

FIG. 6

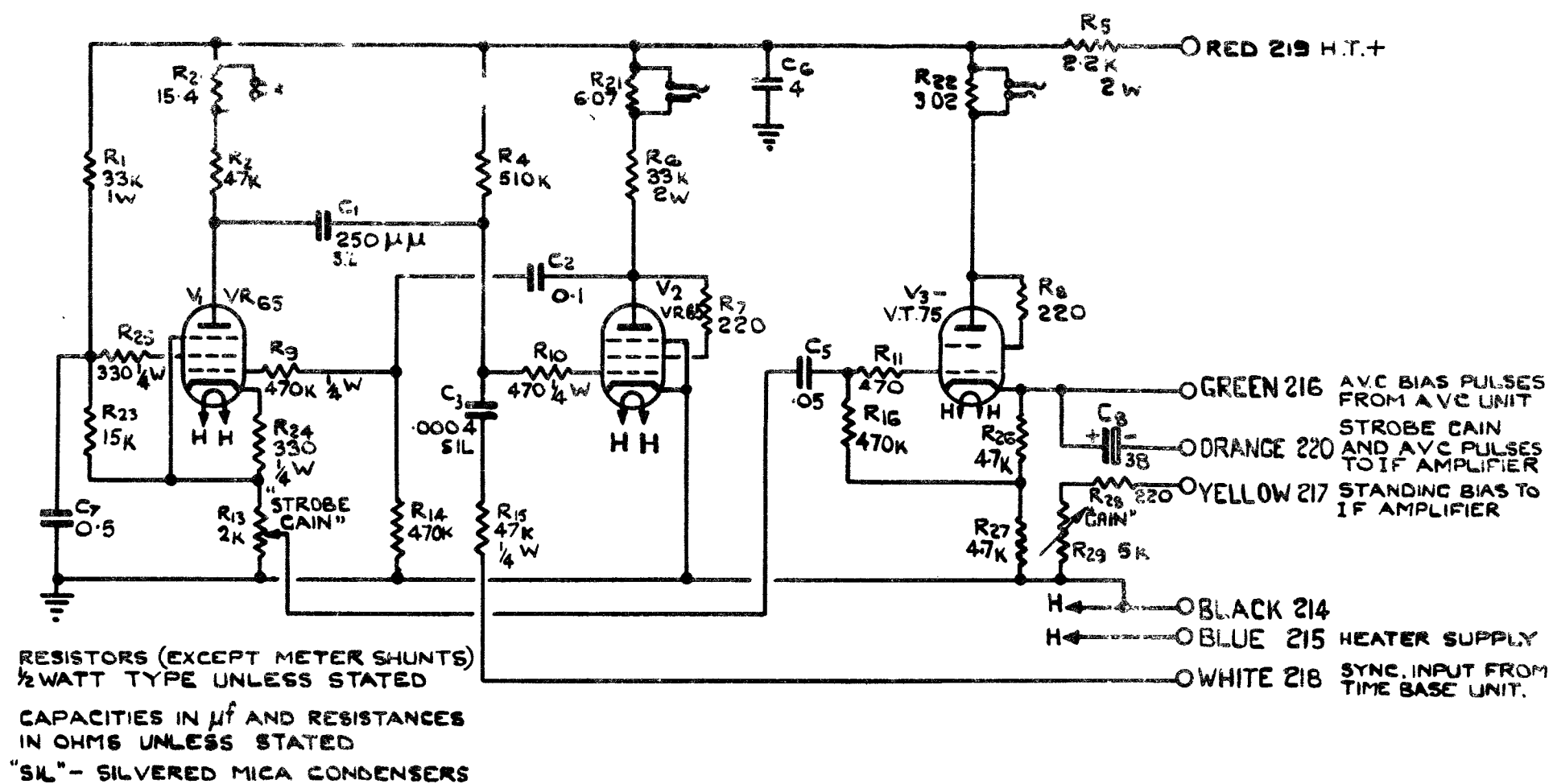
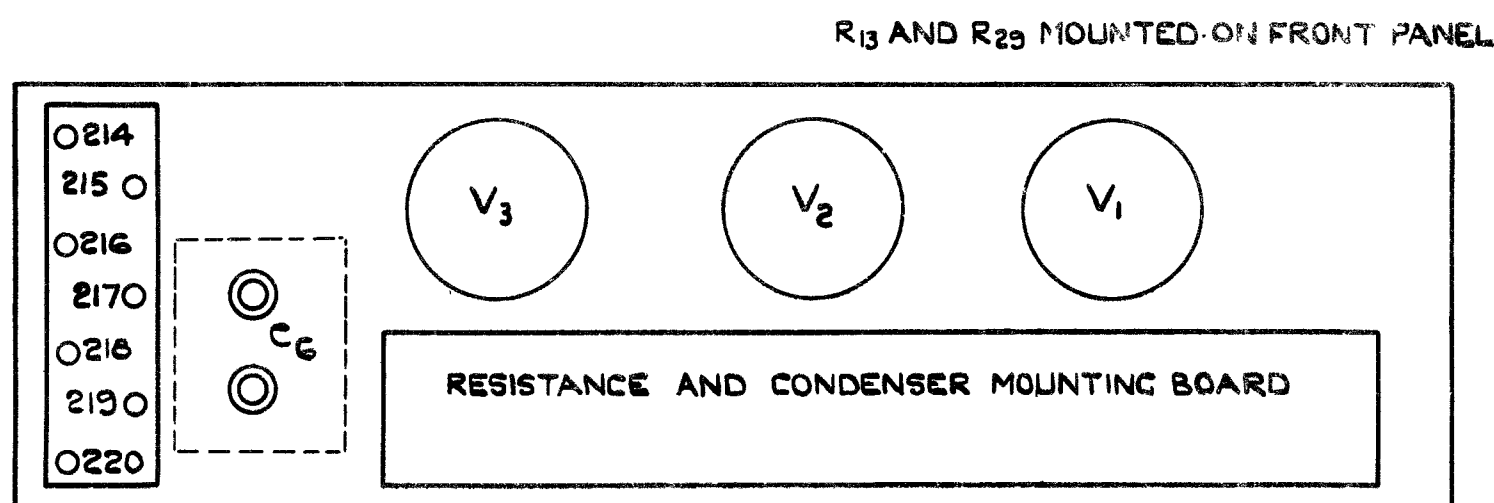


FIG.8 STROBE GAIN CONTROL UNIT CIRCUIT



CHASSIS LAYOUT - REAR VIEW

FIG.10 STROBE GAIN CONTROL UNIT

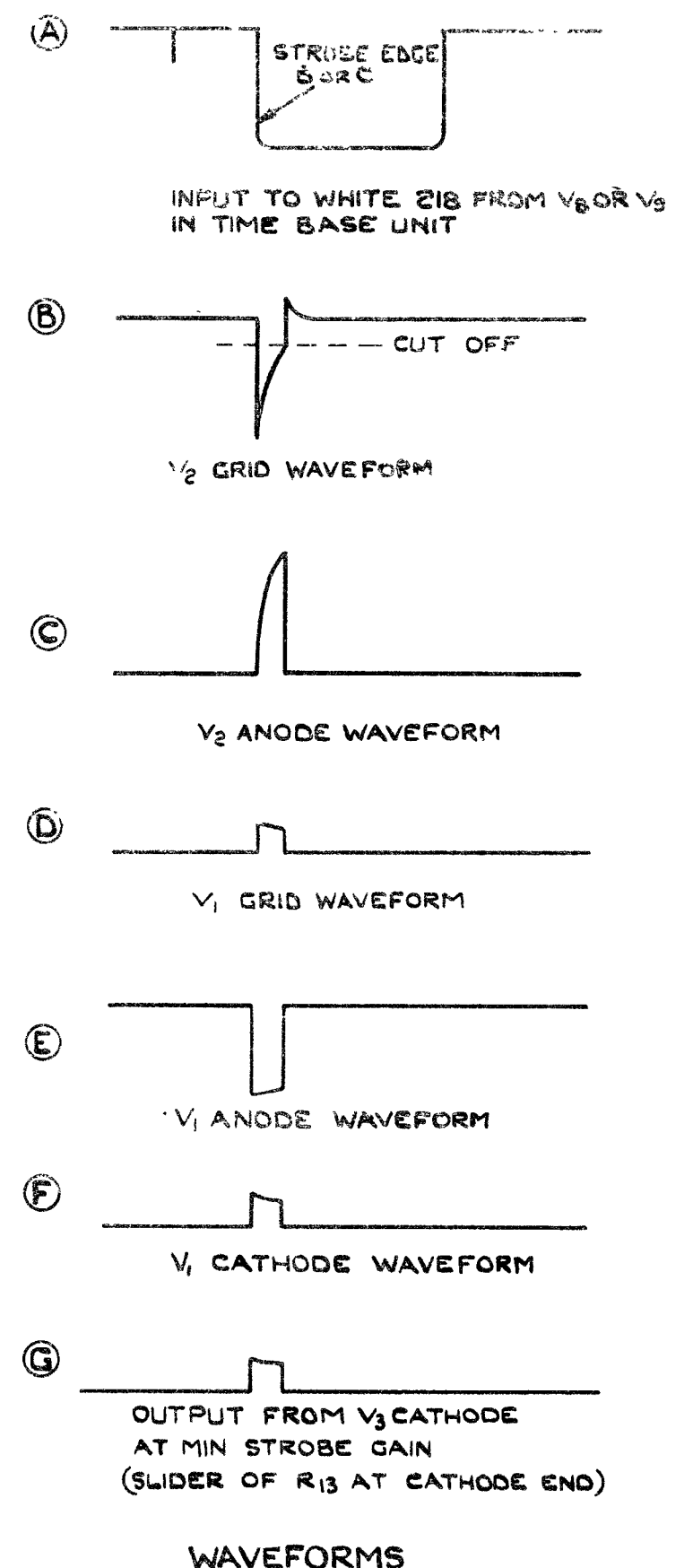
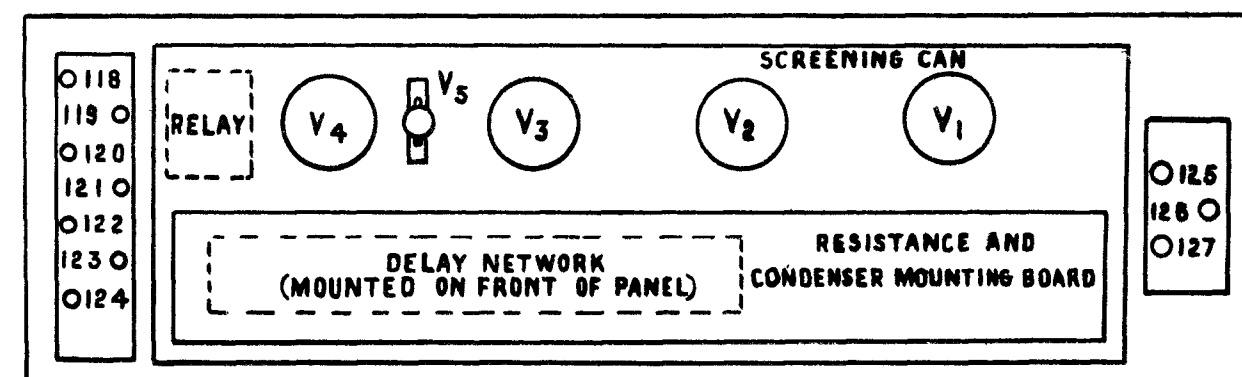
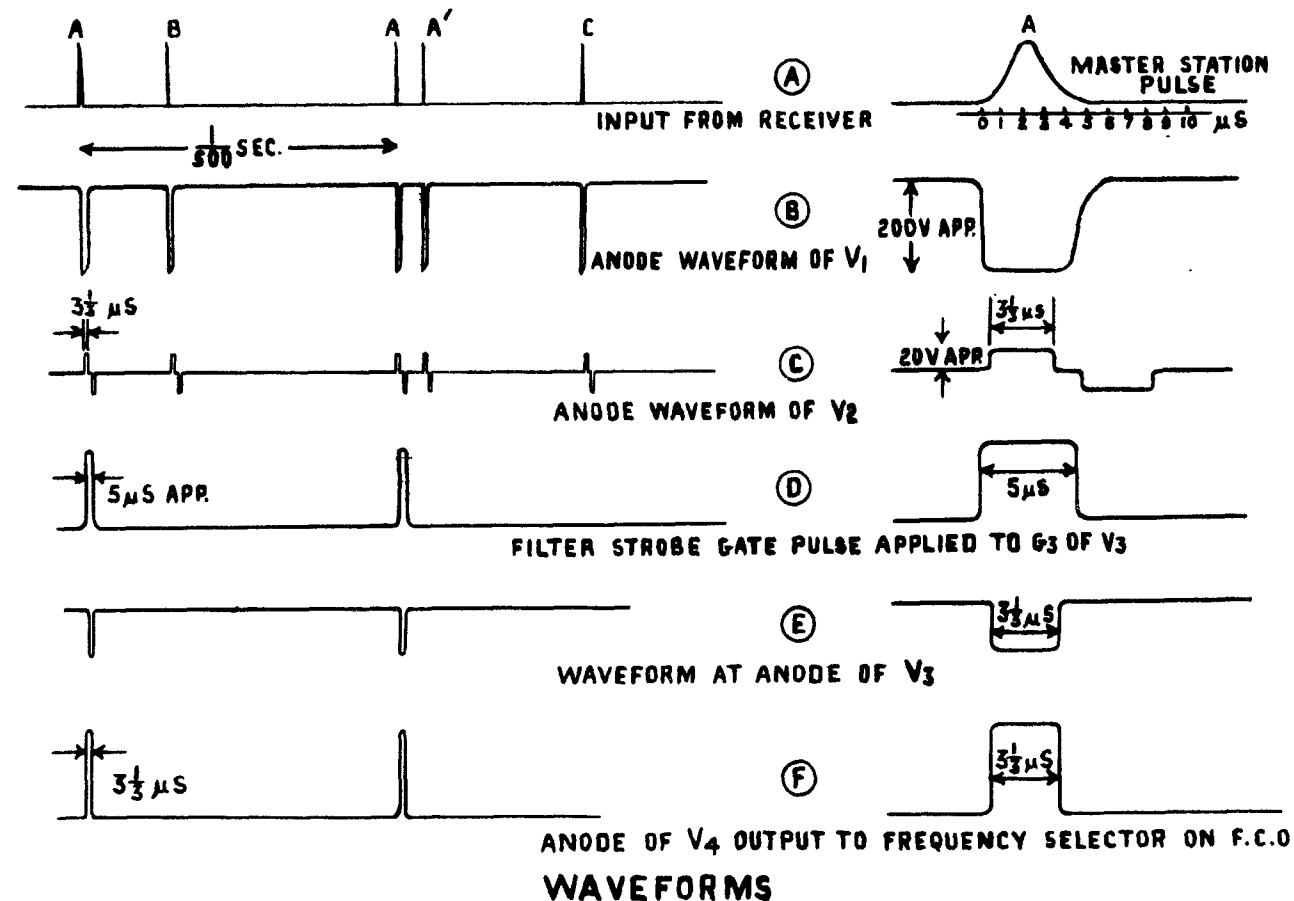
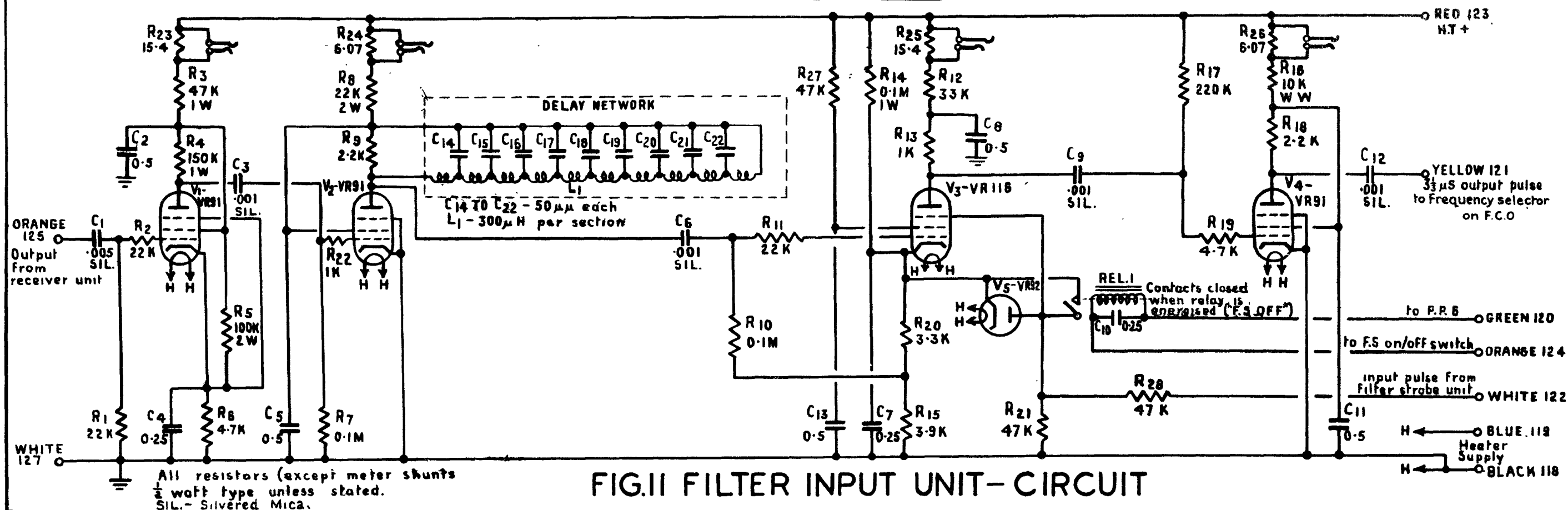
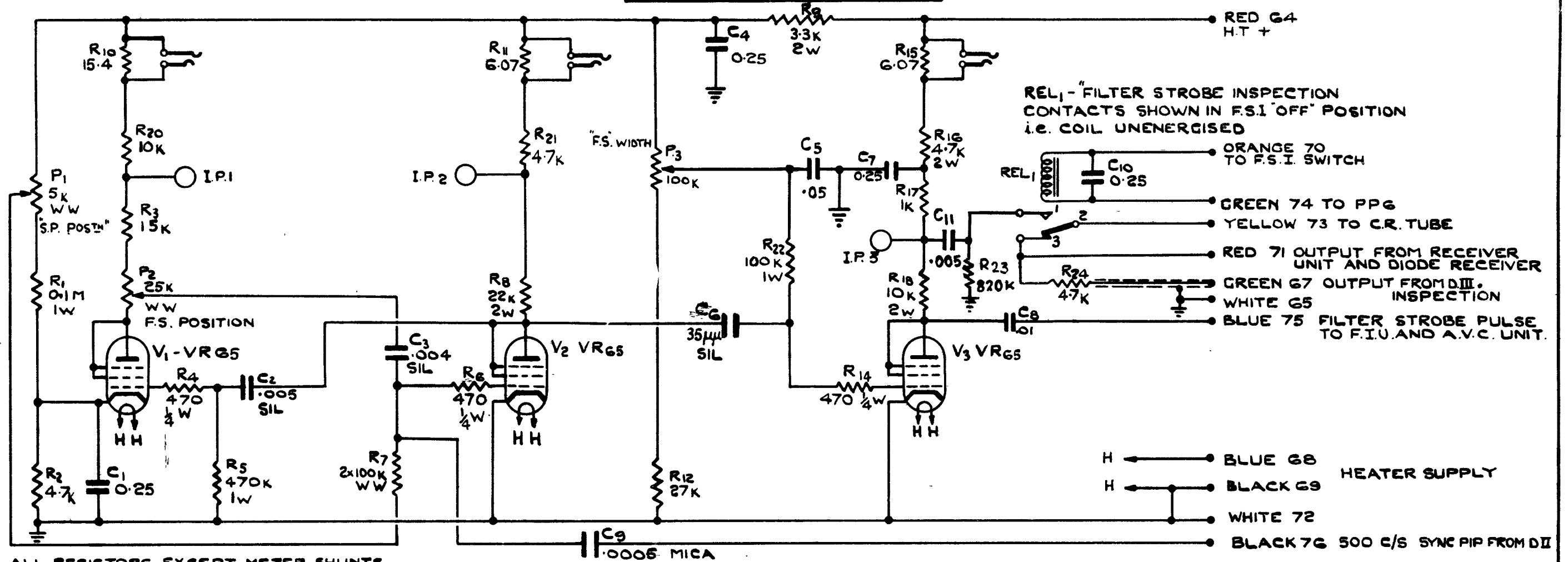


FIG.9 STROBE GAIN CONTROL UNIT





ALL RESISTORS, EXCEPT METER SHUNTS
 1/2 WATT TYPE UNLESS STATED
 "W.W." - WIREWOUND RESISTOR OR POTENTIOMETER
 "SIL" - SILVERED MICA CONDENSER
 "MICA" - MOULDED MICA CONDENSER

FIG. 14 FILTER STROBE UNIT

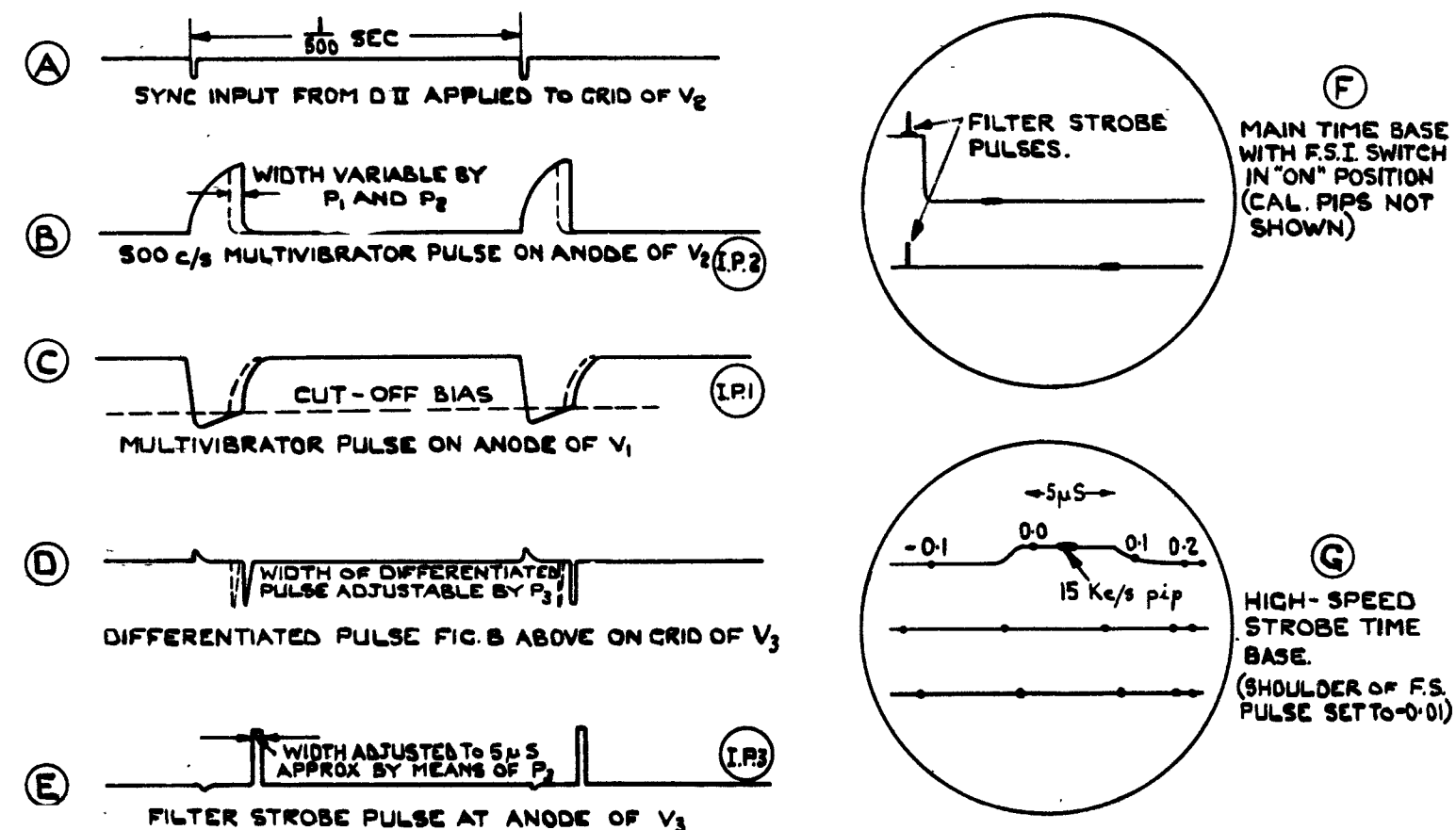
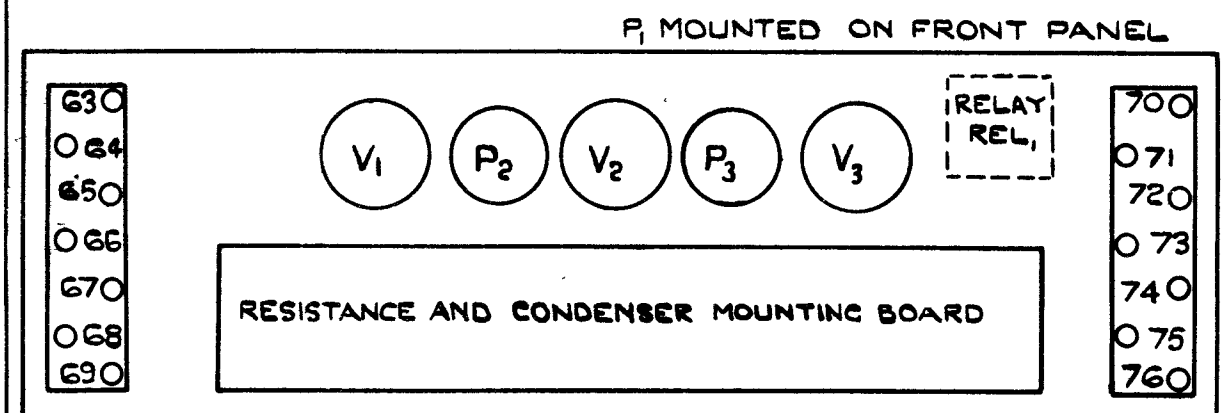


FIG. 15 FILTER STROBE UNIT-WAVEFORMS



CHASSIS LAYOUT REAR VIEW

FIG. 16 FILTER STROBE UNIT-LAYOUT

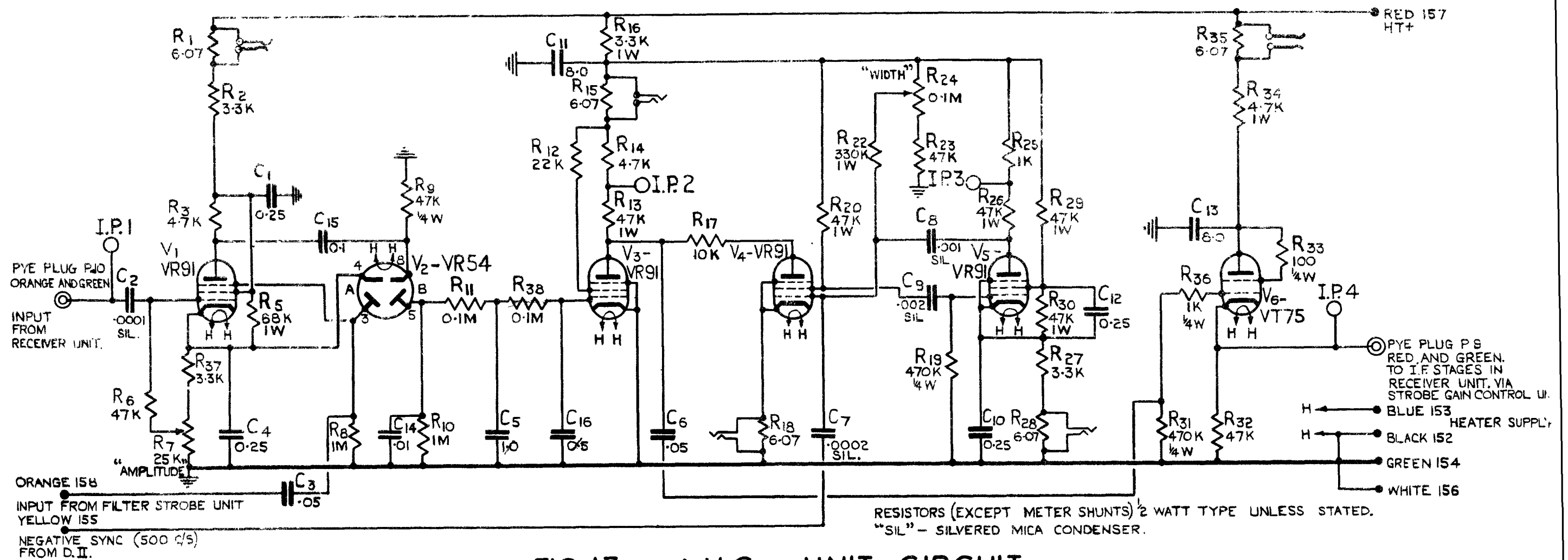


FIG.17 A.V.C. UNIT CIRCUIT

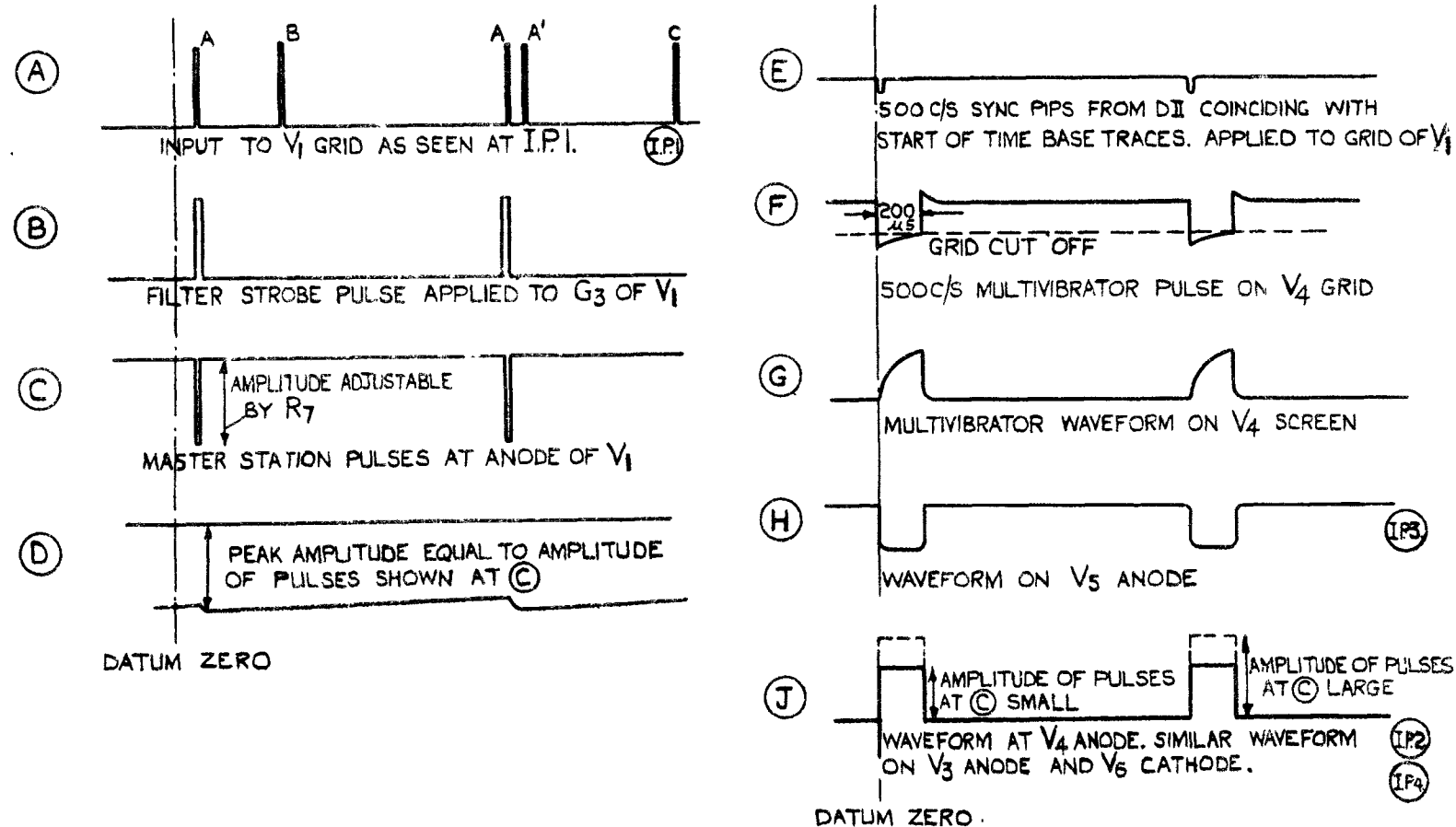


FIG. 18 A.V.C. UNIT WAVEFORMS

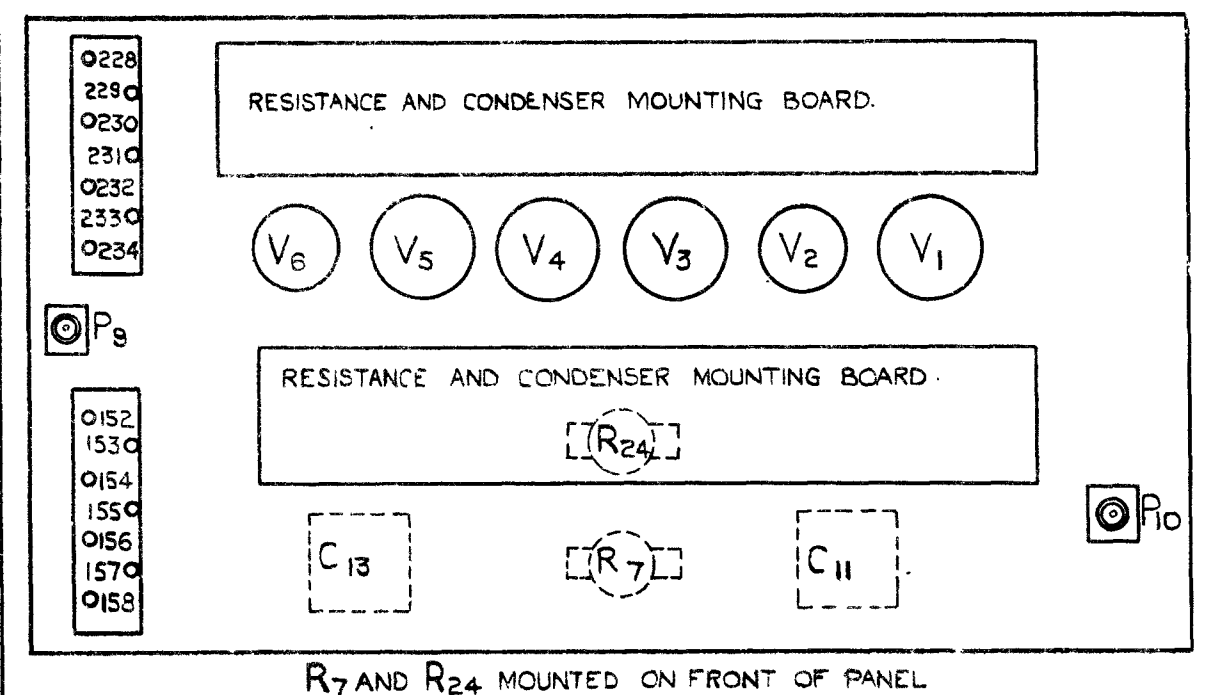
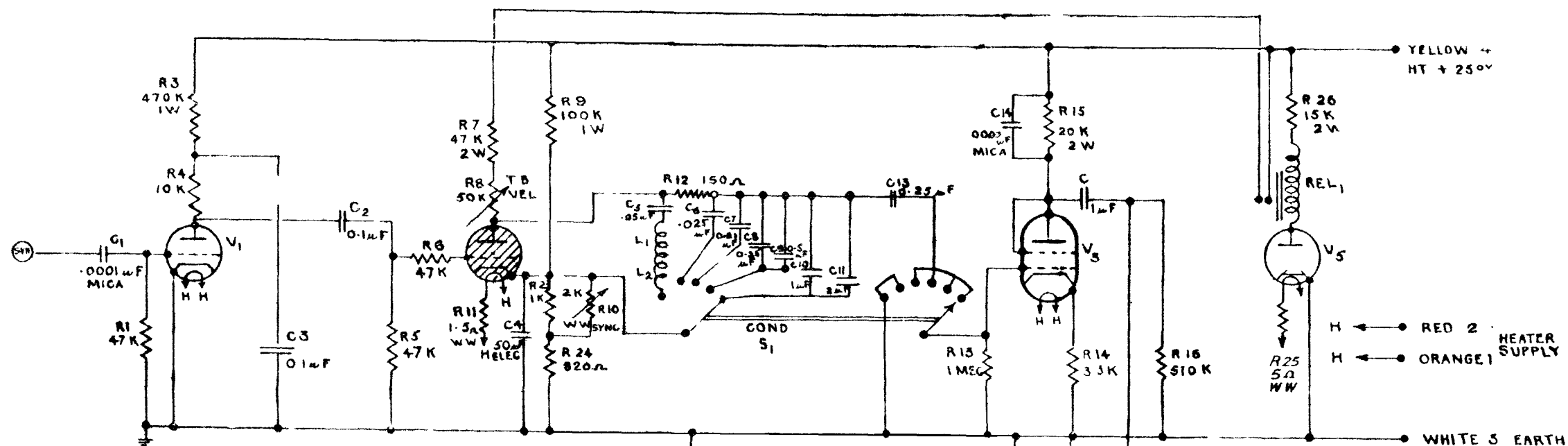


FIG. 19 A.V.C. UNIT LAYOUT



RESISTORS $\frac{1}{2}$ W UNLESS OTHERWISE STATED.

VALVE TYPES.

- V₁ - H65 or VT 75
- V₂ - T41 or VGT 121
- V₃ - KT 63 or 6V6G
- V₄ - VCR 138
- V₅ - D42

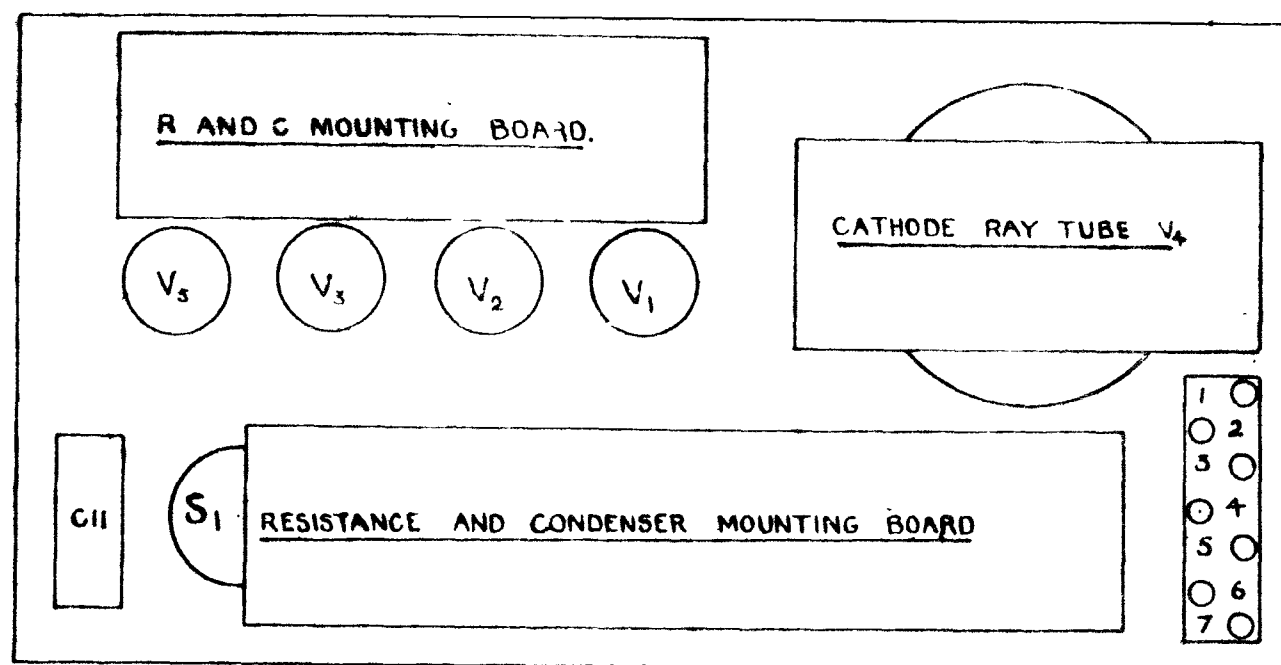
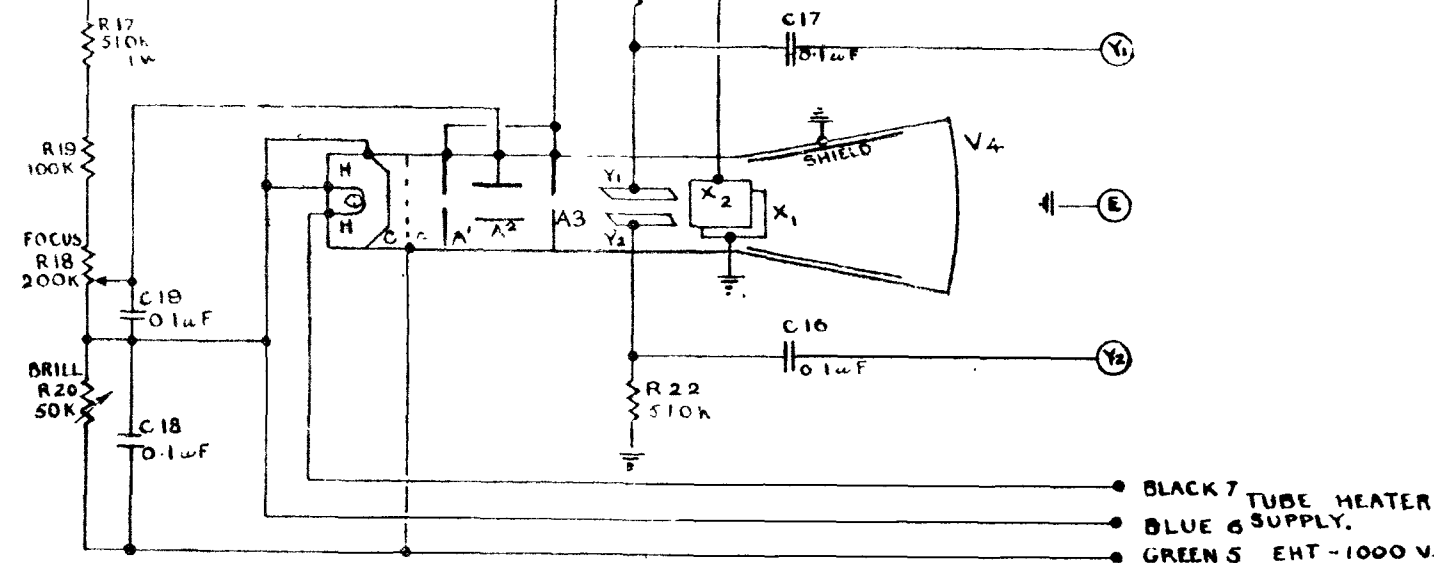
COILS L₁ L₂ ARE DEFLECTOR COILS
MOUNTED ON NECK OF CRT

(SYM) (Y₁) (Y₂) (E) ARE INSULATED

TERMINALS MOUNTED ON FRONT PANEL

WW - WIREWOUND RESISTANCE.

ELEC - ELECTROLYTIC CONDENSER



R₈ R₁₀ R₁₈ R₂₀ ARE MOUNTED INSIDE FRONT PANEL.
CHASSIS LAYOUT. REAR VIEW.

OSCILLOGRAPH
UNIT CIRCUIT

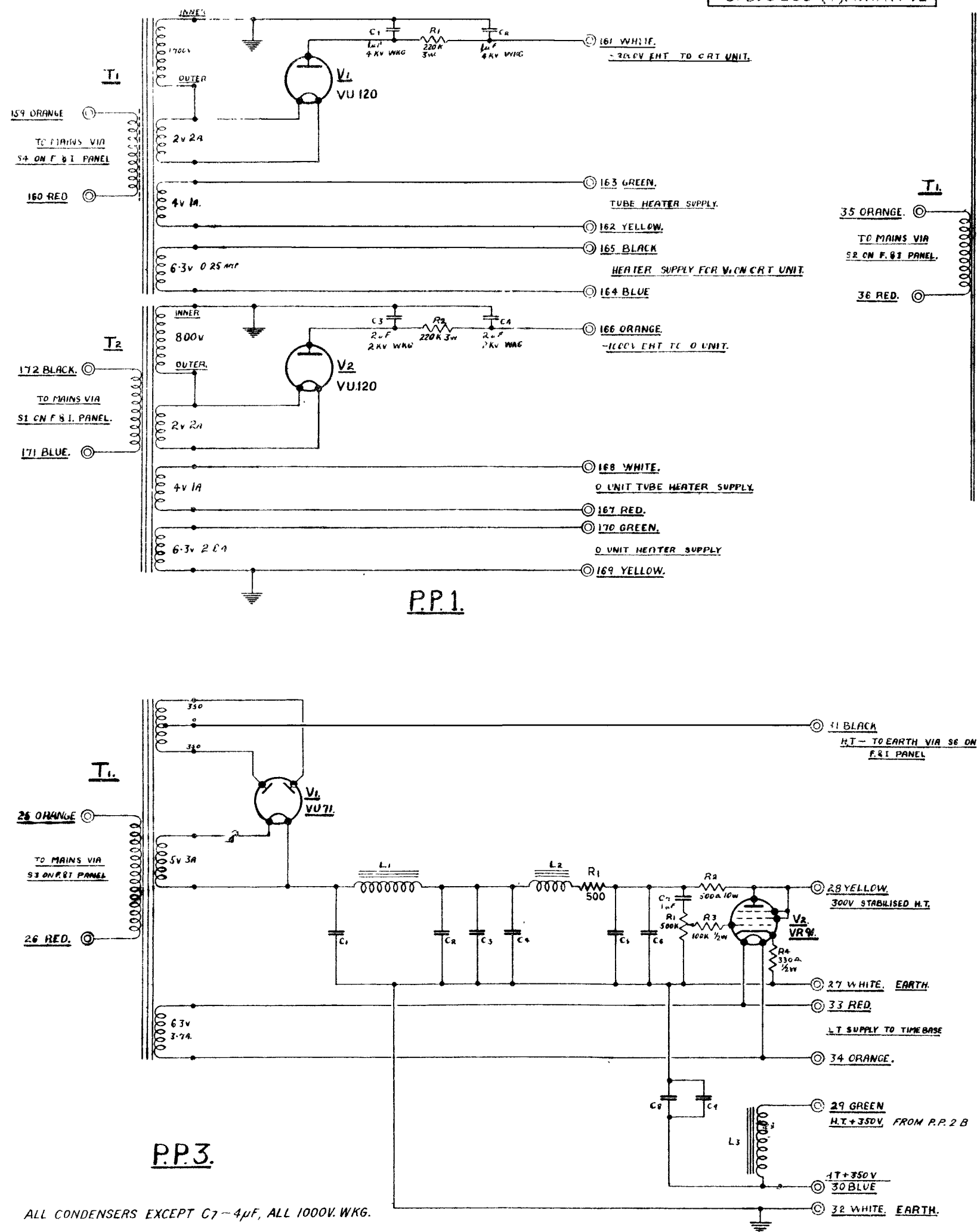


FIG. 38 POWER PACKS P.P.1, P.P.2 AND P.P.3 CIRCUITS

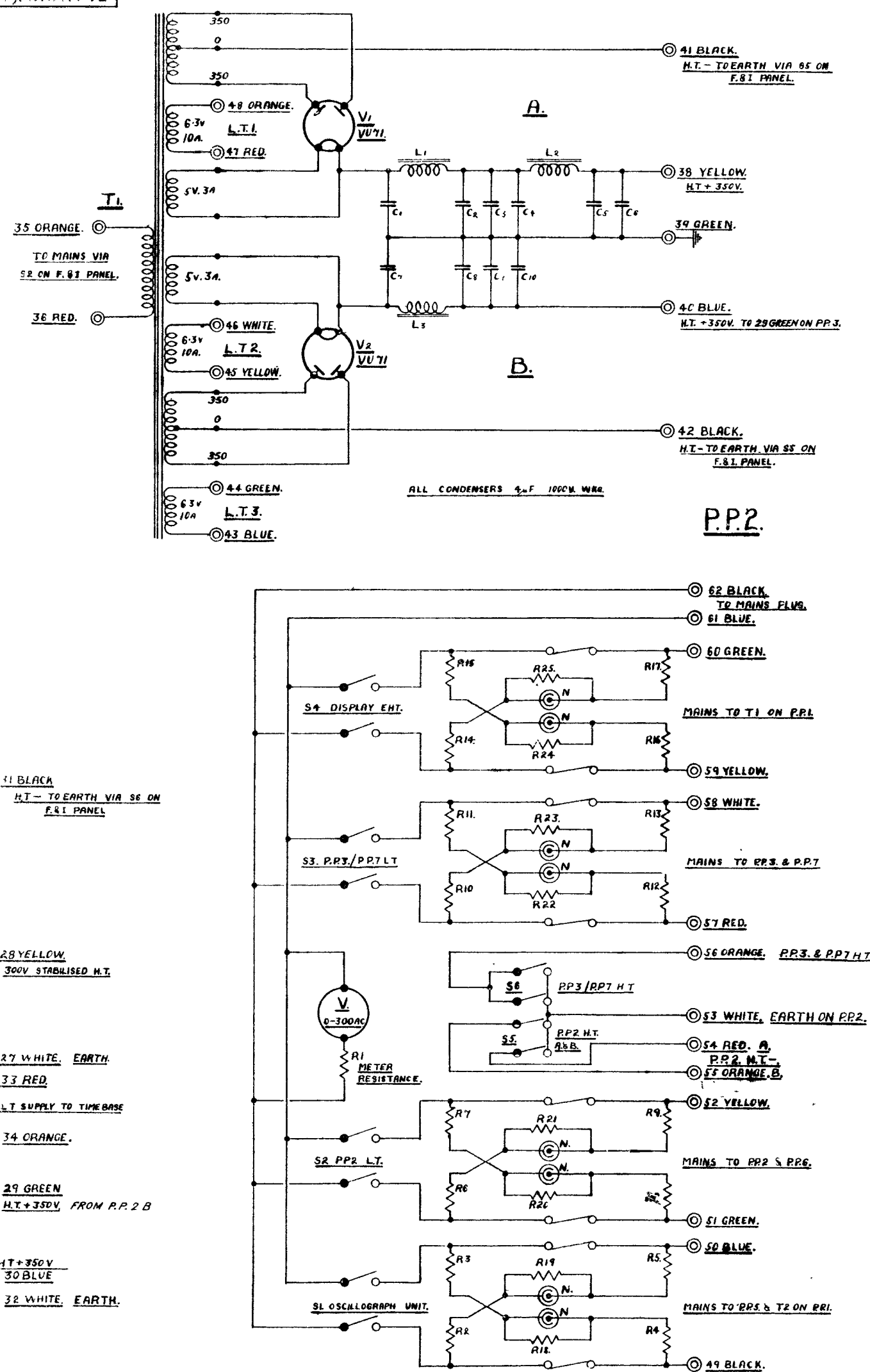
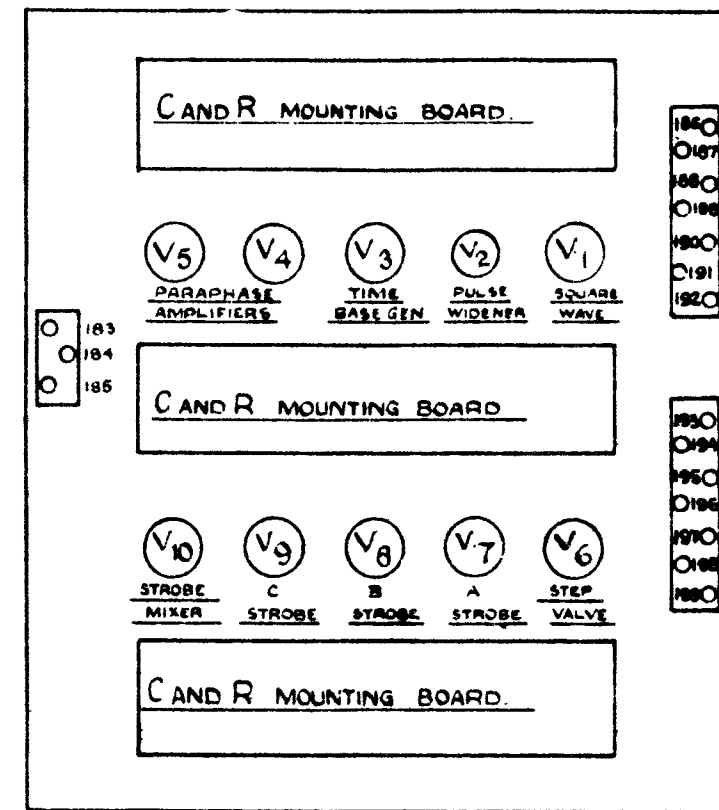
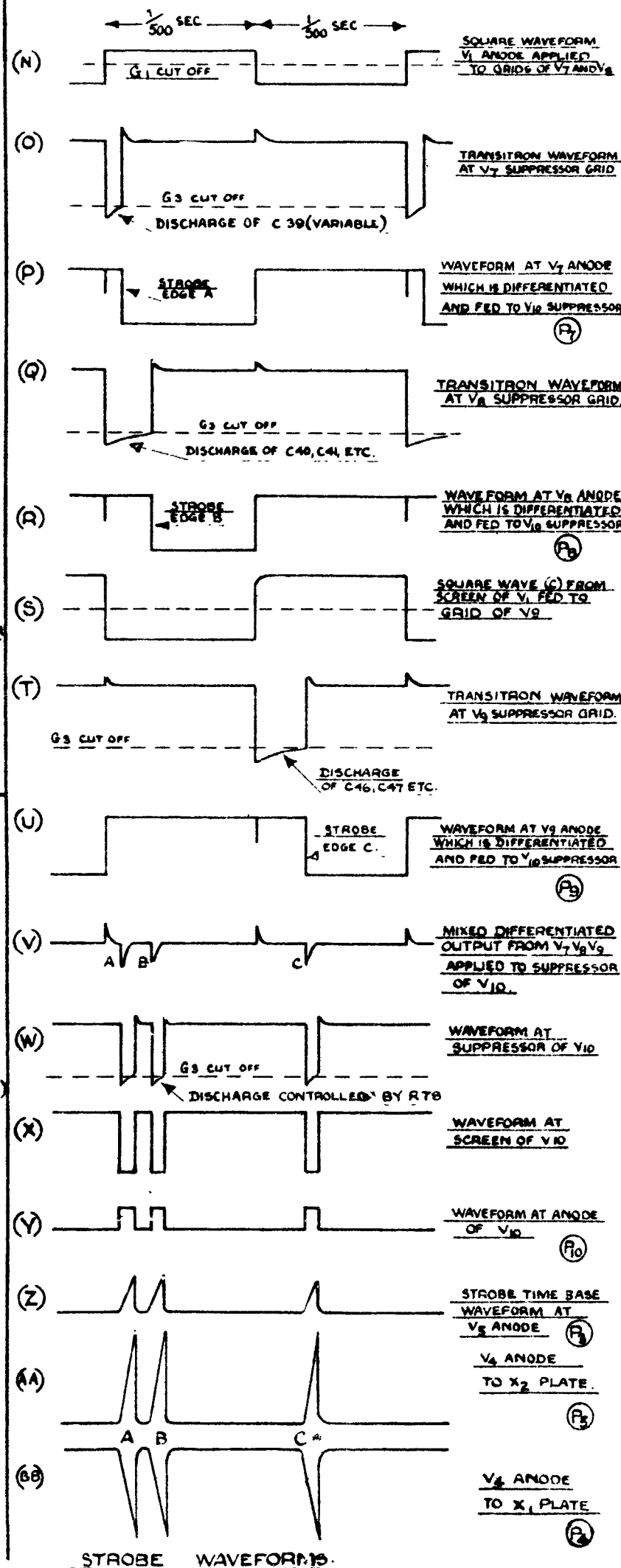
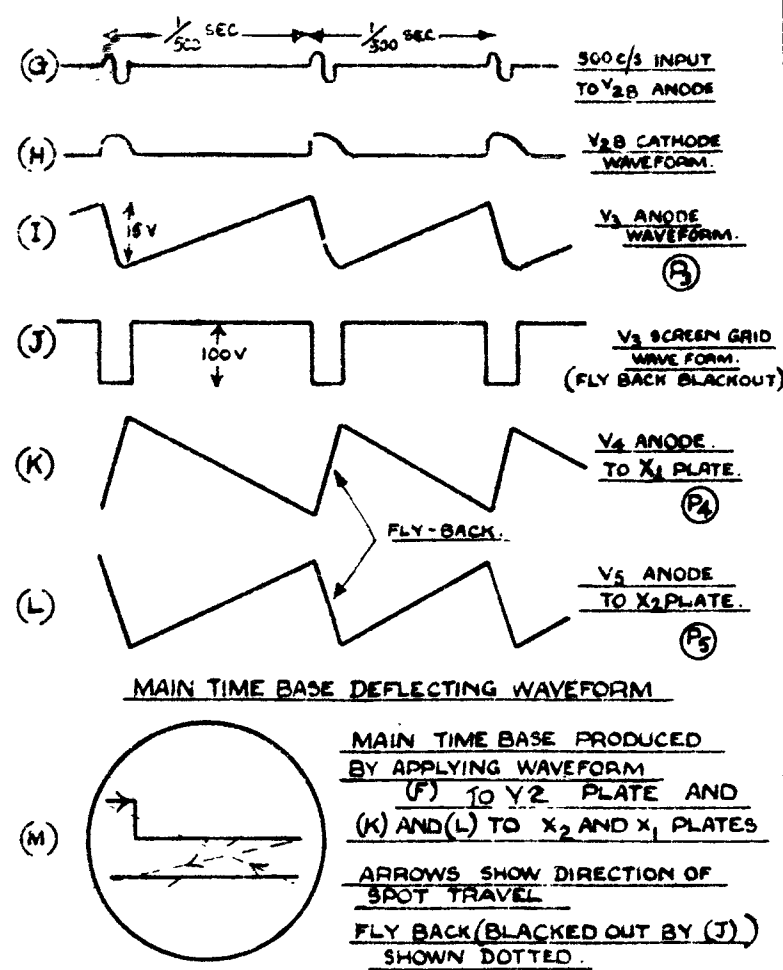
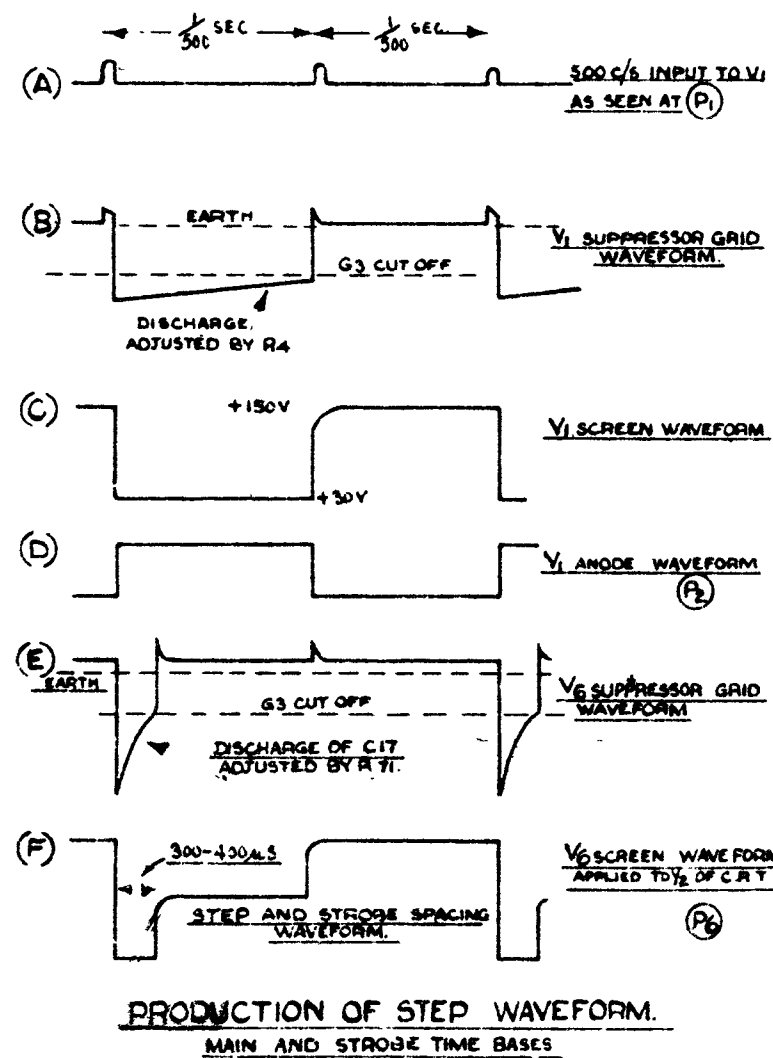


FIG. 39 - FUSE AND INDICATOR PANEL CIRCUIT



CHASSIS OF TIME BASE UNIT-REAR VIEW

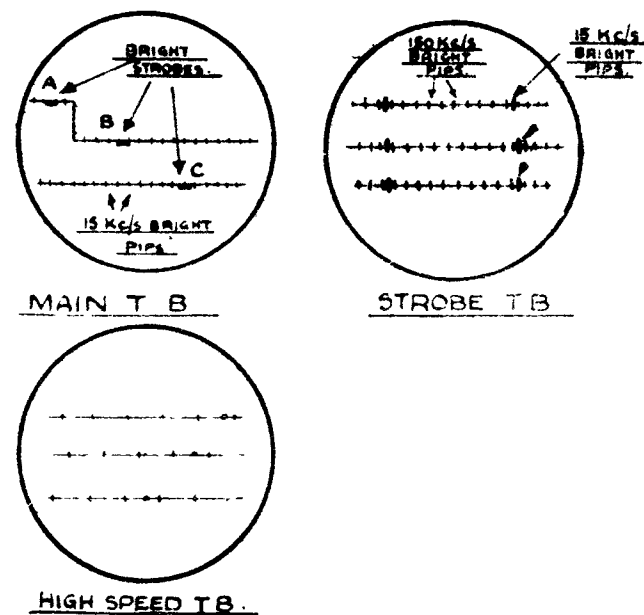
TIME - BASE WAVEFORMS

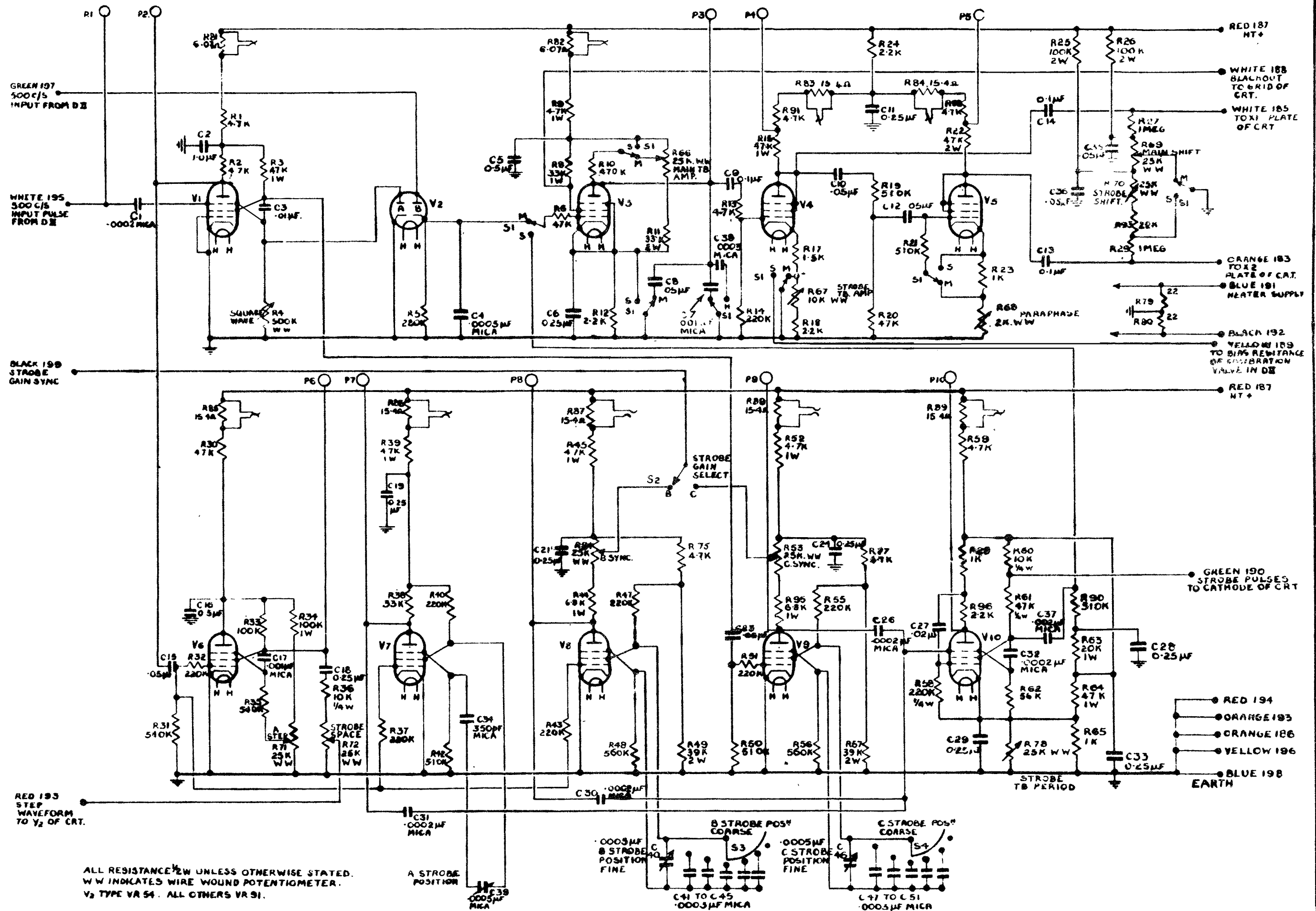
(A) TO (F) AND (N) TO (Y) INCLUSIVE ARE THE SAME IN MAIN AND STROBE POSITIONS.

(G) TO (L) OCCUR ONLY IN MAIN POSITION.

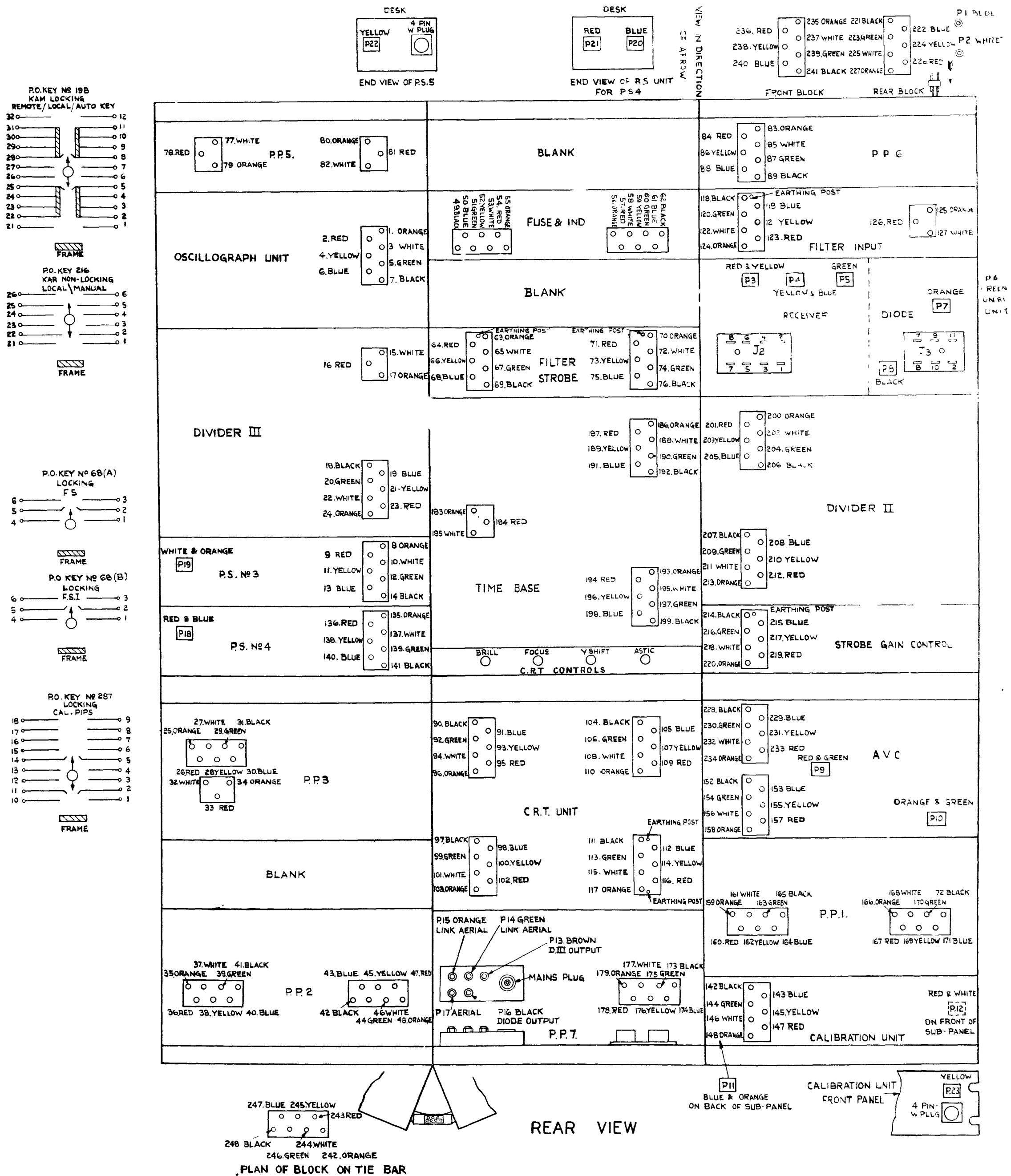
(Z) TO (BB) OCCUR ONLY IN STROBE POSITION.

HIGH SPEED STROBE WAVEFORMS ARE SIMILAR TO (Z) (AA) EXCEPT THAT THE DURATION OF THE PULSES IS SHORTER. HENCE THE SLOPE OF THE PULSE FRONTS IS STEEPER.





S.D.O295(I),CHAP. 12



TERMINAL REFERENCE

FIG.44